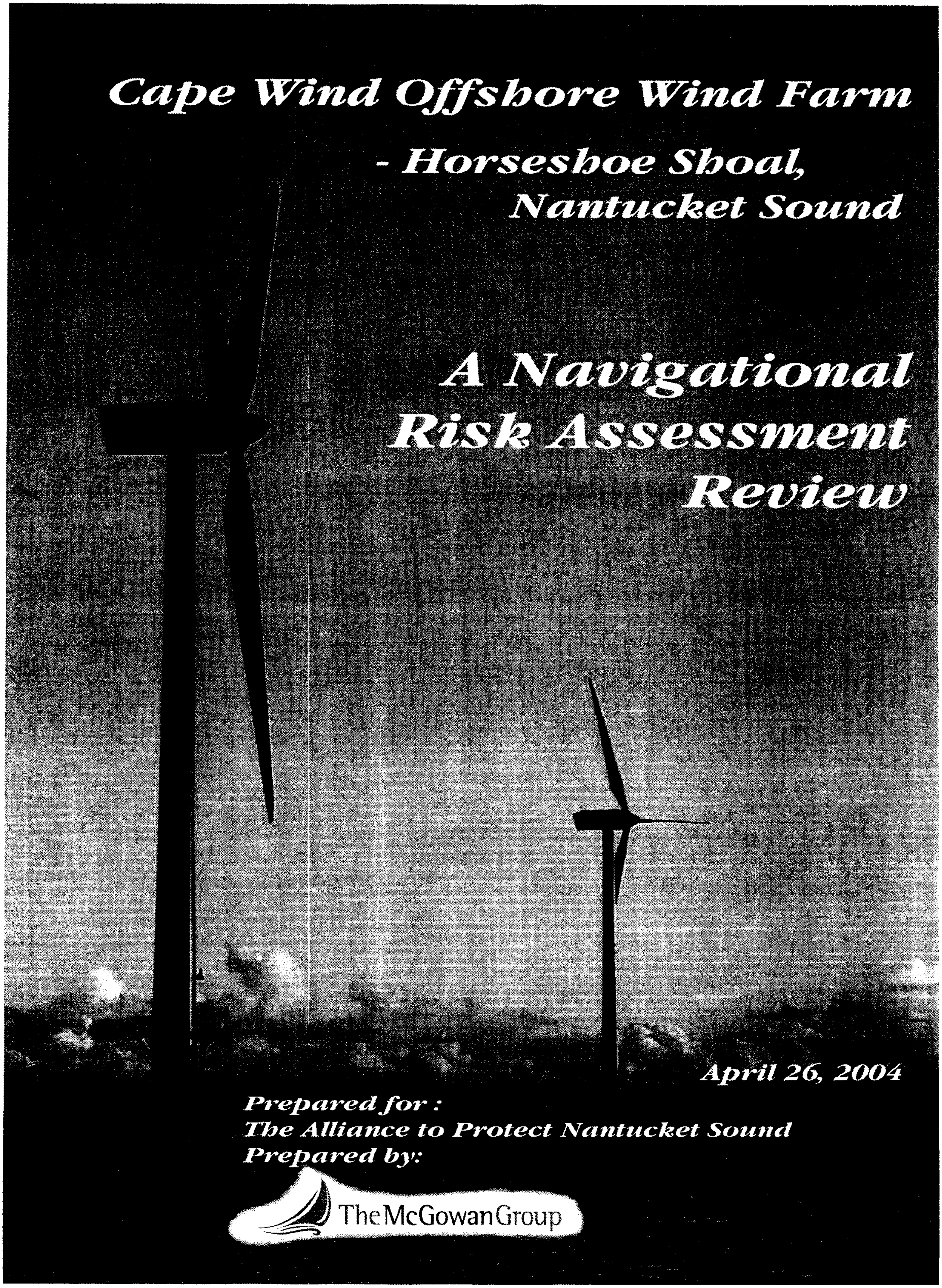

Cape Wind Offshore Wind Farm
- Horseshoe Shoal, Nantucket Sound

A Navigational Risk Assessment Review

April 26, 2004

Prepared for :
The Alliance to Protect Nantucket Sound
Prepared by:

The McGowan Group

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Cover photographs: front, Blythe Offshore wind farm; rear, clockwise from top-left, passenger vessel, M/V CLIPPER ADVENTURER; fishing trawler; J boat; tanker, M/V GREAT GULL, recreational boat and family.

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EXECUTIVE SUMMARY

In November 2001, Cape Wind Associates, LLC applied to the US Army Corps of Engineers and to the Commonwealth of Massachusetts for a permit to construct a commercial scale, wind energy generation project (wind farm) offshore in Nantucket Sound to supply the New England power grid. The Army Corps of Engineers (ACOE) established and leads an interagency cooperative group of US government and Commonwealth agencies in the preparation of an Environmental Impact Statement (EIS) for this permit application.

ESS Group, Inc. on behalf of Cape Wind Associates, LLC, prepared a "Navigation Risk Assessment, Cape Wind Project, Nantucket Sound"[1]. ESS Group, Inc. submitted this document to the ACOE in response to requirements set by the US Coast Guard, Captain of the Port.

The McGowan Group, LLC was retained by the Alliance to Protect Nantucket Sound in November 2003 and requested to provide independent review and comment on the Cape Wind navigational risk assessment. This report offers the results of that review. This report focuses on the navigation safety impacts of the Cape Wind project; particularly with regard to commercial vessels, and to a lesser extent, to commercial fishing and recreational boating.

This McGowan Group report consists of two main components. The first is an examination of international navigation risk assessment methods and safety standards and identification of "best practices" associated with offshore wind farm development. Specific examples from the United Kingdom and Denmark were reviewed. The second segment of the report compares these international standards and practices to those required of the Cape Wind project by the US Coast Guard. A topic-by-topic critique of the Cape Wind assessment is made and compared to an international and US Coast Guard baseline and includes a comprehensive review of gaps and user impacts.

Based on its review and assessment, The McGowan Group draws and records the following significant conclusions:

- The United States is far behind many other countries in providing a national framework to prioritize, promote, and regulate offshore wind energy generation facility development.

- Cape Wind's project at Horseshoe Shoal and its alternative projects at Tuckernuck and Handkerchief Shoal have been placed adjacent to Nantucket Sound's environmental and navigational critically designated Main Channel.

- Cape Wind's proposed Horseshoe Shoal location is at odds with common international practice and threatens disruption of the Main Channel as a marine transportation route. The Tuckernuck Shoal and Handkerchief Shoal alternative sites face similar risks and pose the same potential disruption of marine traffic, as the Horseshoe Shoal location.

- The Cape Wind assessment fails to declare the need for and impact of extensive vessel exclusion and mitigation measures commonly employed internationally to safeguard maritime safety and protect the marine environment.

- Cape Wind's proposal for a Nantucket Sound site is fatally flawed in that it appears incompatible with marine transportation activity and poses unnecessary and unacceptable risks to cruise and ferry vessel, oil transport, fishing and recreational users.

- Cape Wind proposes an inferior tower structural design, which may catastrophically fail if struck by known marine threats.

- The Cape Wind assessment severely underestimates the safety and pollution consequences including loss of life and injury resulting from vessel collisions with a wind tower or with their rotating blades.

- The Cape Wind assessment fails to explore the negative impact to the Nantucket Sound fishing industry by acknowledging that these projects will effectively cut-off all trawling/dragging within the entire confines of the wind farm.

The McGowan Group's full report on the Cape Wind Navigational Risk Assessment for Nantucket Sound is contained in the pages that follow.

INTRODUCTION

In November 2001, Cape Wind Associates, LLC applied to the US Army Corps of Engineers (New England Region) and to the Commonwealth of Massachusetts for a permit to construct a commercial scale wind energy generation project (wind farm) offshore in Nantucket Sound for the New England power grid. The Army Corps of Engineers (ACOE) established, and serves as the lead agency on, an interagency cooperative group of US government and Commonwealth of Massachusetts agencies assisting the ACOE in the preparation of an Environmental Impact Statement (EIS) for this permit application (see Appendix A). The ACOE, Commonwealth of Massachusetts, and the Cape Cod Commission agreed to jointly coordinate the review of the Cape Wind project and preparation of the Environmental Impact Statement (EIS), Environmental Impact Report (EIR) and the Development of Regional Impact (DRI) report[2].

The US Coast Guard, participating in this process with the ACOE, developed a letter of navigation safety requirements. It later directed that a navigational risk assessment be performed to identify the impact of the construction and operation of a wind energy generation facility (wind farm) covering approximately twenty-four square miles, or approximately 7.5% of Nantucket Sound (see Appendix B).

ESS Group, Inc. on behalf of Cape Wind Associates, LLC, prepared a report entitled "Navigational Risk Assessment, Cape Wind Project, Nantucket Sound" dated August 18, 2003," study and submitted it to the ACOE[1]. The US Coast Guard Marine Safety Office, Providence, RI completed a review of the draft Navigational Risk Assessment (dated June 24, 2003) and issued a letter commenting on the study (see Appendix C). The Coast Guard Marine Safety Office apparently has not formally commented in writing on the final navigational assessment submission dated, August 18, 2003.

The McGowan Group, LLC was retained by the Alliance to Protect Nantucket Sound in November 2003, and requested to provide independent review and comment on the navigational risk assessment based on The McGowan Group's experience in navigational safety and waterway management issues. The McGowan Group, formed by Rear Admiral John F. "Jack" McGowan, is a maritime consulting firm specializing in developing and integrating solutions to meet transportation, security, and port development needs with environmental expertise. The McGowan Group represents a multi-disciplinary team with experience ranging from ship design and operation to port planning and development.

This report offers a review of the Cape Wind navigational safety risk assessment. Other areas that the Cape Wind project may impact, such as fishing and recreational boating were examined only as they related to navigation. The EIS process described by the ACOE indicates that impacts in these and other areas will be separately assessed (see Appendix D).

INTERNATIONAL STANDARDS

A general survey of offshore wind farm proposals and established projects conducted by The McGowan Group for this project, revealed that most countries, when considering such installations, have established formal, national regulatory and in some cases statutory regimes, standards and procedures. An examination of these regimes provides a gauge of the depth and breadth of standards and procedures that European countries have enacted when faced with proposals similar to that of Cape Wind Associates for Nantucket Sound. A review of these international efforts also helps identify examples of "best practices" that can benefit the process of consideration in the Cape Wind case, or perhaps serve as an example of a national set of standards that should be implemented in the United States. This observation is consistent with views expressed among the members of a peer review committee established by the Army Corps of Engineers (ACOE) for the purpose of providing guidance on the review of the Cape Wind project. The peer review committee report noted that:

> *"...safety aspects concerning collisions of ships with wind turbine structures need to be addressed in the design phase. As the North Sea in Europe is a very intensively used shipping 'lane', experiences to be gained here will be very relevant to other areas"*[3].

International Review and Licensing Processes

From an international perspective, it is noteworthy that the European Commission of the European Union has for some time directed (EU Directive 97/11/EC) the performance of Environmental Impact Assessments in instances of design and construction of wind energy facilities including those for an offshore application. Additionally, the European Commission has and continues to sponsor an active Research & Development program covering all aspects of wind farm facility applications including turbine, rotor, and blade design, as well as the overall operation and management of wind farm facilities.

Regulatory and licensing regimes are well established in countries such as Denmark that is currently the home of the world's greatest number of offshore wind farm facilities. Other countries (i.e. Netherlands and Germany) are reviewing and updating their national legislation based on their own experience with these facilities or that of their neighbors. The United Kingdom (UK) and Ireland have adopted proactive processes for offshore wind facilities and have recently revamped their national regulatory and licensing regimes governing this area[4]. The majority of coastal European countries have established national processes for government review, selection, approval and licensing of proposed offshore facilities.

Unlike the decentralized process being followed in the United States for the Cape Wind proposal, the efforts in European countries are focused and directed by a central government authority. Many implement energy initiatives enacted by the host country that promote alternative energy production sources. An exception is Sweden's review process that operates under a decentralized authority at the municipal level.

While an exhaustive analysis to determine the full extent that other countries have regulated offshore wind farms would be prohibitive, the UK provides a representative example of a European program governing offshore wind farm development. The UK's overall evaluation of offshore wind farms is managed and regulated by the Department of Trade and Industry (DTI). A recent DTI report[5] provides a detailed view of the UK's legislative and regulatory development impacting wind farms as well as its initial efforts to support the industry. The United Kingdom's regulatory and licensing regime was reviewed and selected as a representative example.

The navigation safety standards for a detailed navigational risk assessment and maritime evaluation procedure are managed by the UK Department for Transport. The following is a brief overview of the standards applied in the UK governing navigational risk assessments and risk mitigation procedures for proposed offshore wind farm facilities.

Navigation Risk Assessments - The United Kingdom Experience

The UK has several branches of government that are concerned with the overall aspects raised by an offshore wind farm proposal including navigation safety, pollution, environmental concerns, and search and rescue. Among the UK's maritime agencies are the Maritime and Coastguard Agency, Aids to Navigation Commissions, Health and Safety Executive, Local Harbour Authorities and others. The Maritime and Coastguard Agency (MCA), under the Department for Transport, serves as the principle maritime coordinating entity and has recently published comprehensive navigation safety standards that apply to wind farms to be built or operated off the UK coast (see Appendix E).

Some of the major highlights in these standards, which were revised in July 2003, require a developer to:

1) Perform an "up to date traffic survey ... include all commercial traffic, but also fishing vessels and pleasure craft."

2) "Identify in the risk assessment ... increase in risk of collision between vessels and wind energy facility structures ... under all reasonably foreseeable weather and tide height conditions or between vessels under all conditions."

3) Identify "limitations on the use of such sites and adjacent waters for non-transit purposes e.g. fishing, day cruising, ... dredging, anchoring "; and

4) Evaluate and propose "protective measures and safety zones ... include recommendations for the safe operating distances from the structures. These may include the size and types of vessels and those activities that may continue to operate and exercise rights of navigation."

The following table breaks down the United Kingdom's Maritime and Coastguard Agency (MCA) navigation safety requirements into their major regulatory elements and briefly summarizes the core of the standard. The depth of the table reflects the comprehensive nature of the MCA navigation safety regime that applies to offshore wind energy facility proposals.

Table 1. United Kingdom Requirements for Proposed Wind Energy Facility Developments

	UK/ MCA Required Element *	Additional Detail *
1)	Perform marine traffic survey Account for routes & density Account for seasonal variances & events	– at least 4 weeks
2)	Account for commercial vessels	
3)	Account for fishing & pleasure vessels	
4)	Conduct safety risk assessment Account for aggravate/mitigate weather current, depth ...	– explore 3 options
5)	Identify risk/frequency of collision	- vessel-to-structure - vessel-to-vessel
6)	Identify marine traffic changes	
7)	Identify site use limits	- include fishing, day cruising, racing etc.
8)	Identify Search and Rescue impact	
9)	Prove turbine & power shut-down • Minimum stop time • Minimum blade clearance • Stop blade control • Manned control center	– see detailed Annex* - 60 seconds – clear all vessels w/ minimum of 18m (59 ft.) – within 5 degrees of blade arc – 24 X 365
10)	Provide emergency access & egress from tower structure	– ladders & hatch
11)	Evaluate electronic interference	– include AIS
12)	Evaluate radar impacts	– include blind spots
13)	Evaluate sonar impacts	
14)	Evaluate electromagnetic impact	– include effect on navigation compass
15)	Evaluate visual navigation site blocking	
16)	Evaluate acoustic masking	
17)	Evaluate tidal stream impact	
18)	Evaluate siltation changes	
19)	Evaluate wind mask & shear	– on nearby vessels
21)	Evaluate and propose vessel mitigation & protective measures	– see detailed Annex*
22)	Propose vessel safety zones &/or safe operating distances	–Annex* has risk class of sites: "High/Med/Low"

Notes: *Refer to Appendix E

Mitigation Strategies – International Applications

The purpose of a generic risk assessment effort is to identify a project's risk and to present a mechanism to control the risks identified. Mitigation strategies and recommendations, as a means to manage risk, should accompany a risk assessment. This same approach should be applied in assessing the navigation risk of a proposed offshore wind energy facility.

Once identified, described and evaluated, the navigational risks associated with the construction and operation of an offshore wind farm can be matched with specific mitigation strategies to attempt reduction of the risks to an acceptable level. The challenge to designers, owners, managers, communities and authorities is to weigh the effectiveness and practicality of proposed strategies against their cost and to determine if business, economic and operating limits are satisfied while the elements of public safety and welfare are also met.

Risk mitigation strategies are applied in other countries during the three major stages of development of an offshore wind farm (design, construction and operation) to address inherent navigation safety risks. Different strategies are appropriate during each phase, and in some cases have been codified in some, i.e. European, standards and regulations that govern offshore wind farm development.

A review of operating offshore wind farms and those currently under development revealed a range of strategies that have been employed to mitigate navigation safety risks.

Design Phase Mitigation Strategies
Typically designers and regulatory authorities identify and apply limits or criteria at the earliest stages of design to eliminate or significantly reduce unacceptable navigation risk factors. These limits are commonly applied prior to or in the early site selection and preliminary design processes. The United Kingdom, in offering up sites owned by the government for possible wind farm development, eliminated sites that were regarded as environmentally sensitive and those sites whose sea-lane or seabed activity was incompatible with wind farm development. Sites developed in Denmark and other locations were selected due to their great distance from existing maritime channels and fairways. Others have been situated in shallow water to take advantage of natural protection from ship collisions.

Early design decisions regarding wind turbine generator propeller length and hub height or the method for laying transmission cables, can mitigate or exacerbate navigation risk factors from the beginning of concept development. Site evaluation and selection criteria should be identified early in the onset of a project and applied as pass/fail criteria to eliminate sites that are incompatible with safety, the environment or the public welfare. Building in mitigating factors, or wholly eliminating selected navigation risk factors, at the outset of the design process avoids the need for expensive and disruptive technical add-ons or operating limits during the later stages of development, or during operation. Land area restrictions, as an example, can be applied from the onset of design to mitigate risk. For example, the UK began its offshore wind farm program by imposing a maximum area limit (10 km^2) and a limit to the number of wind turbines (30) for their development on UK sovereign coastal zone sites[6].

Construction Phase Mitigation Strategies

An examination of existing offshore wind farms and those under development reveals an almost universal mitigation strategy employed while offshore wind farms are being constructed. Navigation warning lights and buoys are installed as well as aerial warning lights throughout the construction area and on any deployed vessels. Ship and aircraft navigation warnings and bulletins accompany the physical warning devices.

Typically, shipping, fishing and recreational boating are excluded from an area under development for the duration of construction. Various measures of excluding ships and boats are utilized. Some specify a blanket prohibition covering the entire site of the facility and others identify specific distances from the tower positions or cable laying activities. The UK's Scarweather offshore wind farm employed a total ban of all vessels during construction. Scotland's Solway Firth facility banned all vessel navigation within 350 meters (380 yards) of the tower sites and all trawling and anchoring within 100 meters. Denmark imposed a ban on all trawling activity within the Horns Rev wind farm site. Ireland's Arklow Bank wind farm bans all vessel activity within its boundaries for the life of the project.

Operating Phase Mitigation Strategies

A wide range of mitigation strategies has been employed when offshore wind farms reach the operating phase. Air and marine navigation aids such as lights, sound devices, buoy markers and navigation chart notes and warnings are common to all facility sites. Both blanket and limited anchoring and trawling bans have been variously imposed (see Appendix E). Several countries have applied limited prohibitions barring vessel activities within a fixed distance of the structures and undersea cable tracks[7].

It should be noted that while construction limits and exclusions might be inconvenient – they pass with time. However, operating phase mitigation procedures, limits and exclusions tend to be permanent for the life of a project (typically 20-25 years). Requiring watch standers in the control tower carries a significant economic impact for the wind farm operator. Excluding fishing activity or limiting private boating access for navigation safety carries its own impact on the fishing community and on the boating public.

Mitigation Requirements – A United Kingdom Case Study

The UK's Maritime and Coastguard Agency (MCA) requirements for offshore wind farm developments follow the general risk management principal of matching specific risks with specific mitigation measures (see Appendix E). This matching of risk assessment elements with mitigation options is clearly evident in the "Required Elements" summarized in Table 1. Emergency mechanisms and procedures naturally flow from the navigation risk process established in the MCA's requirements.

Additionally, these MCA navigation and safety requirements assign individual site risk classifications to each proposed wind farm development. Site risk classifications are based on a wind farm's water depth and its proximity to "shipping routes, channels and recognized fairways." The Annex of the MCA standards defines Lower, Medium and Higher risk wind farms and follows each designation with specific examples for risk mitigation (see Annex 2 to Appendix E).

The MCA requirements identify " Higher risk" wind farms as "structures situated in areas with more than seven meters (twenty-three feet) of water below chart datum close to or across shipping routes." Cape Wind's proposed wind farm for Nantucket Sound would clearly receive the UK's designation as "Higher Risk." The MCA requirements follow this risk designation with a list of "Examples of Additional Marine Routeing Measures ..." or navigation risk mitigation options. The complete listing can be found in Annex 2 of the MCA standards; its more significant elements are captured below:

- *"... safety zones up to 50 meters;*
- *... monitoring by radar, Automatic Identification System transponders;*
- *... continuous watch by multi-channel VHF;*
- *... use of guardship or guardships ;*
- *...declaration of "Area to be avoided (ATBA) around the whole wind farm and up to 500 meters from the extremities;*
- *... continuous vessel monitoring/information service using radar;*
- *... closure of nearby shipping routes where there are suitable alternatives... "*

RISK ASSESSMENT "BEST PRACTICES"

At present there does not appear to be any body of standards that have been assembled, validated or promoted by the growing alternate energy industry, or by manufacturers and suppliers to that industry, that govern or guide a navigation risk assessment for offshore wind farm development sites. Similarly, there is no body of recognized experts that offers guidance in this area other than Det Norske Veritas, an international classification society that has published guidelines for the design of wind turbines and is developing rules for offshore wind turbine structures[8].

Expertise has been built in the private sector in those countries that have spawned offshore wind farm facilities and specifically in the engineering and service sectors that have driven or supported those projects. One such engineering company (Ramboll – Virum, Denmark) with significant credentials arising from experience with the offshore wind industry has publicly released its risk assessment methodology. Samples of its assessment methods for navigation safety risk and for marine pollution risk can be found at Appendices F and G, respectively.

Ramboll and other commercially applied methodologies provide a "Best Practice" guide exemplifying a proven approach where no other industry standards have been made mandated or published. The methodologies described in the Appendix F and G also provide important examples of the application of the prescribed international standards and requirements covered in the previous section.

Navigation and Ship Collision Risk Analysis – A Danish Model

In their paper, "Ship Collision Risk for an Offshore Wind Farm," the authors, C.F. Christensen, L.W. Andersen & P.H. Pedersen, present a method for performing a navigation ship collision risk analysis and apply an established model for calculating collision frequencies (see Appendix F). They emphasize the results of this risk analysis as the first step in evaluation of a potential site for a wind farm and additionally to form the basis for planning mitigation strategies to reduce collision frequencies. Their method was applied to the preliminary design phase of the Rodstand offshore wind farm in Denmark, where seventy-two turbines of approximately two megawatts each were planned, for a combined capacity of 150 megawatts. The towers formed a nine by eight grid spaced at intervals similar to the Cape Wind project, which is one-third mile, by one-half mile apart. The farm covered a total area of approximately nine square miles where the depth ranged from sixteen feet to twenty-eight feet. A transformer module or control tower was also constructed in the field. Construction of the farm was to span a period of three years. The Rodstand wind farm is located approximately 6.5 nautical miles from shore and approximately 4.4 nautical miles from the nearest shipping lane.

The Christensen, Andersen and Pedersen methodology and model is driven by the following four inputs identified as key to producing a sound analysis and decision model:

- Vessel traffic, in terms of the amount and distribution of vessel traffic in the area near the wind farm;

- Navigational routes and environmental conditions in the vicinity of the wind farm – including wind, wave and current in the area;

- Geometry of the wind farm and the water conditions in the area; and

- Vessel accident probabilities, common failures leading to accidents and their scenarios (based on casualty history).

Christensen, et. al have designed a maritime collision and risk model with a method of determining vessel collision frequency and collision consequence. The Christensen, et. al, methodology includes a risk mitigation feature to determine the effect of mitigation strategies on both the frequency and consequences of collisions. Gathering the above information is perhaps the most important step in assuring the model's value when it is applied at other wind farm locations. Christensen, et. al, determined not only the vessel type and size but also the routes taken, distance from the wind farm and the number of trips made.

As a last step in their methodology, Christensen, et. al, determined the type and likelihood of failures that vessels navigating in the area could suffer. They considered all manners of possibilities from loss of propulsion, loss of steering, human error, as well as the tendency of ships to "wander" due to heavy wind and current in the area. Conservatively, they assumed that all vessels suffering a failure that could reach the wind farm would collide with one of the towers. They accounted for the distance that a "stricken" vessel would drift before an anchor could be deployed or before additional vessels would arrive to render aid. Finally they used industry-recognized rates derived from actual ship casualty data and calculated the probability of failures occurring.

The results from applying the Christensen, et. al, methodology will vary widely based on each wind farm's design and location and the vessel traffic in the area. However, some of the observations they made as a result of applying their risk methodology are nonetheless revealing:

- Human error had the strongest probability for causing failure, followed by loss of propulsion, with steering failures being the least likely of the three;

- The number of vessel collisions with towers is extremely dependent on the distance at which vessels routinely pass by the wind farm; and

- Actual vessel casualty records for the location should be researched and used to "truth-check" the results obtained from the model.

The results that Christensen, et. al, obtained were completely dependent upon the actual routes and distances vessels took when passing the proposed wind farm location. A second independent check of vessel transits was made using actual radar plots of the area over an extended period of time. Their initial assumption that vessels safely used the internationally designated transit route some 4.4 nautical miles from the wind farm proved wrong. A substantial number of vessels were found to pass within only hundreds of yards of the proposed location yielding a totally different and higher risk result. Based on the new data, Christensen, et. al, concluded that a complete re-evaluation of collision risk was necessary. Christensen, et. al did not present the consequences of a vessel collision with a tower through either an assessment of damage to the tower or to a vessel, its contents or to crew and passengers.

Marine Pollution Ship Collision Risk Analysis – A Second Danish Model

The paper, "Risk of Oil Pollution due to Ship Collision with Offshore Wind Farms," provides an another "best practice" example in risk assessment (see Appendix G). In it the authors, S. Randrup-Thomsen, Lars Andersen and Jette Kjaer Gaarde, present a method of performing a risk analysis to determine the risk of oil pollution resulting from a vessel colliding with a proposed wind farm tower. Their method was published for the Horns Rev wind farm located twenty-two nautical miles off the coastal city of Esbjerg in Denmark. The farm has eighty turbines and towers for a total capacity of 150 megawatts. The towers form a ten by eight grid, spaced at even intervals of 1,840 feet. The farm covers a total area of about eight square miles with water depths ranging from twenty to forty-three feet. A transformer station or control tower is also located in the field. The Horns Rev wind farm lies roughly one nautical mile from the nearest shipping lane.

The methodology of Randrup-Thomsen et. al, is very similar to that used in the previous paper (Christensen, et. al.) on navigation risk analysis. The same strong emphasis is placed on defining the number, type, and size of vessels as well as their contents and the specific routes taken in passing the wind farm location. The frequency of vessel collisions is calculated taking into account the environmental conditions (i.e. wind, wave and current) and the design of the wind farm. The authors add in two new dimensions to the vessel collision model, namely oil spill scenarios and oil pollution consequences, to predict the oil pollution result from the forecast collisions.

Randrup-Thomsen et. al. developed their oil spill scenarios to consider the consequences of the vessel/tower collisions to determine the amount of hull damage suffered by a colliding vessel. In short, they produced a conservative, comprehensive methodology building on the Christensen, et. al, navigation risk model to predict consequences (oil pollution and vessel damage) of vessel collisions in offshore wind farms.

Their or a similar methodology, if applied in the Cape Wind assessment, would have greatly enhanced its accuracy and immediately revealed the severity of a marine safety or pollution incident resulting from a vessel collision with a Cape Wind tower structure.

OVERVIEW OF UNITED STATES STANDARDS AND BEST PRACTICES

Presently there are no specific United States federal or state statutes designed to govern the construction and operation of offshore wind electrical generating facilities. Various bills were introduced or were pending before Congress in 2003 that would have established specific legislative authority (as exists for deepwater port facilities or for oil and gas exploration facilities on the outer continental shelf) but none were passed. Similarly no specific regulatory regime or review process has been established for the siting, design or operation of these offshore facilities.

The US Army Corps of Engineers (ACOE) has taken the lead among the concerned federal agencies to evaluate the Cape Wind Associates project application to construct a wind farm in Nantucket Sound (see Appendix D). Under Cape Wind's proposal, the Nantucket Sound offshore wind farm would be the first such facility in the United States and worldwide it will be exceeded in size by only the Arklow wind farm off the coast of Ireland.

Cape Wind Associates will provide the data and analysis to the Corps covering the environmental assessment for the proposed project. The Commonwealth of Massachusetts agreed to cooperate and coordinate their needs with the Corps in the review of a joint federal/state Environmental Impact Statement / Environmental Impact Report[2].

In October 2003, the ACOE identified a total of five additional optional sites to be further explored and compared by Cape Wind Associates in the EIS against their Horseshoe Shoal proposal. The ACOE identified the following as impact areas that need to be addressed and compared in exploring the preferred and optional sites: avian, marine/habitat, fisheries and benthos, aviation, telecommunications, navigation, socio-economic, cultural/historic properties, aesthetic/landscape/visual, recreation, noise and vibration, water quality, electric and magnetic fields, air and climate, safety, engineering and economics (see Appendix D).

The US Coast Guard, as a participant in the ACOE review process, established analysis requirements (Appendix B) to gauge the impacts of the Cape Wind project "on navigation safety, and also on search and rescue, operations, communications, radar and positioning systems." The Coast Guard identified specific elements in its requirement for a navigational safety risk assessment. In the following table, these Cost Guard requirements are placed side-by-side and compared with those of the UK as contained in the MCA requirements discussed earlier.

Table 2. United Kingdom/MCA Standards vs. U S Coast Guard Requirements

	Required Common Element	UK/MCA Standard*	USCG Requirement**
1)	Perform marine traffic survey	Yes – at least 4 weeks	Yes
	Account for routes & density	Yes	Yes
	Account for seasonal variances & events	Yes	Yes
2)	Account for commercial vessels	Yes	Yes
3)	Account for fishing & pleasure vessels	Yes	Yes
4)	Conduct safety risk assessment	Yes – explore 3 options	Yes
	Account for aggravating or mitigating weather current, depth etc. conditions	Yes	Yes
5)	Identify risk/frequency of collision	Yes – vessel-to-structure	Yes
		- vessel-to-vessel	Yes – and groundings
	Evaluate collision consequence	**No**	Yes
	Evaluate damaged tower structure integrity	**No**	Yes for a range of vessels speed/size
6)	Identify marine traffic changes	Yes	Yes
7)	Identify site use limits	Yes - include fishing, day cruises, racing etc.	Yes – constraints on navigation & anchoring
8)	Identify Search and Rescue impact	Yes	Yes – in detail
9)	Prove turbine & power shut-down	Yes – see detailed Annex*	**No**
	• Minimum stop time	Yes - 60 seconds	**No**
	• Minimum blade clearance	Yes – clear all vessels w/minimum of 18m (59 ft.)	**No**
	• Stop blade control	Yes – within 5 degree of blade arc	**No**
	• Manned control center	Yes – 24 X 365	**No**
	• Emergency radio guard	Not Specified	**No**
10)	Provide emergency access & egress from tower structure	Yes – ladders & hatch	**No**
11)	Evaluate electronic interference	Yes – include Automatic Identification System	Yes – include Automatic Identification System
12)	Evaluate radar impacts	Yes – include blind spots	Yes – in detail
13)	Evaluate sonar impacts	Yes	**No**

Table 2. United Kingdom/MCA Standards vs. U S Coast Guard Requirements (cont'd)

	Required Common Element	UK/MCA Standard*	USCG Requirement**
14)	Evaluate electromagnetic impact	Yes – include effect on navigation compass	Yes – include compass & navigational systems
15)	Evaluate visual navigation site blocking	Yes	**No**
16)	Evaluate acoustic masking		Yes – of navigational aids
17)	Evaluate tidal stream impact	Yes	**No**
18)	Evaluate siltation changes	Yes	**No**
19)	Evaluate wind mask & shear	Yes – on nearby vessels	**No**
20)	Evaluate impact of ice buildup	**No**	Yes
21)	Evaluate and propose vessel mitigation & protective measures	Yes – see detailed Annex*	**No**
22)	Propose vessel safety zones &/or safe operating distances	Yes –Annex * has risk class of sites: "High/Med/Low" risk	**No**

Notes: * Refer to Appendix E

** Refer to Appendix B

A high degree of similarity in the MCA and USCG requirements is evident from this comparison. One major difference between the two sets of requirements is that the MCA standards require the identification and proposal of mitigating measures as part of the risk analysis, including emergency procedures and systems for stopping the turbines and power generation. The USCG requirements place their major emphasis on risk identification, analysis and specific assessments such as vessel groundings and ice buildup, as a first step.

There is another and perhaps more significant difference between the MCA standards and the USCG requirements for a navigation safety risk assessment for an offshore wind farm. The MCA requirements are national standards that presumably will be uniformly applied throughout the UK. The USCG requirements are local in nature and were designed by the Coast Guard's Marine Safety Office in Providence, RI to apply to the Cape Wind Nantucket Sound proposal. Lacking a national statutory or regulatory regime, there is no assurance that these same USCG requirements should or will ever be used in another part of the US.

As a footnote to this analysis, it should be noted that growing emphasis in the past two years has been placed on the security of important domestic facilities. A selection of Security Zones, Safety Zones and Restricted Areas have been variously employed by the USCG extending security measures to sensitive areas and facilities including total exclusion of maritime users. Neither the Coast Guard nor Cape Wind's assessment makes an evaluation of the future security aspects for the proposed wind farm.

A REVIEW OF A NAVIGATION SAFETY RISK ANALYSIS

The primary objective of this study is to assess the adequacy of Cape Wind's navigation study. International standards and "Best Practices" that apply to offshore wind farms provide a benchmark against which Cape Wind's navigation risk assessment can be measured. Toward that end, a comparison between United States and United Kingdom standards and the ESS study was conducted, and the results are presented in the Table 3 below. The UK MCA standards and the USCG requirements have been combined to eliminate duplication. Where a standard is attributable solely to the UK's MCA standards, highlighting has been applied for emphasis.

A "Yes" designation in Table 3 indicates Cape Wind's apparent full compliance with the combined MCA/USCG requirement. A "No" designation indicates a failure to comply with the combined requirement. "Partial" indicates that a portion of the combined requirement has apparently been met by Cape Wind. The "Unknown" designation reflects that insufficient information was available in the Cape Wind assessment to make a comparison. A "Fails Best Practice" designation was used to indicate that the Cape Wind assessment did not apply or follow a best practice methodology such as discussed in the earlier section and found at Appendix F and G.

Table 3. Comparison United Kingdom/USCG Requirements & Cape Wind's Assessment.

	United Kingdom/MCA Standard* **USCG Requirement****	**ESS (Cape Wind's) Risk Assessment*****
1)	Perform marine traffic survey – for at least a four week period	**Partial**
	Account for vessel routes & density	**Partial**
	Account for seasonal variances & events in vessel activity	Yes
2)	Account for commercial vessels	**Partial**
3)	Account for fishing & pleasure vessels	**Partial**
4)	Conduct safety risk assessment – explore a minimum of 3 options	**Fails Best Practice**
	Account for aggravating or mitigating weather, current, depth etc. conditions	**No**
5)	Identify risk/frequency of collision: vessel to structure; vessel to vessel, and groundings	**Fails Best Practice**
	Evaluate collision consequence	**Partial**
	Evaluate damaged tower structure integrity for a range of vessels' speed and size	**Partial**
6)	Identify marine traffic changes	**Partial**
7)	Identify site use limits - include fishing, day cruising, racing	**No**
8)	Identify Search and Rescue impact in detail	Yes
9)	Prove turbine & power shut-down - see detailed MCA Annex	**Unknown**
	• Minimum stop time – 60 seconds	**Unknown**
	• Minimum blade clearance - clear all vessels w/ minimum of 18m (59 ft.)	**No**
	• Stop blade control – within 5 degrees of blade arc	**Unknown**
	• Manned control center – 24 hrs X 365 days	**Unknown**
	• Emergency radio guard	**Unknown**

Table 3. Comparison United Kingdom/USCG Requirements & Cape Wind's Assessment. (Continued)

	United Kingdom/MCA Standard* USCG Requirement**	ESS (Cape Wind's) Risk Assessment***
10)	Provide emergency access & egress from tower structure – equip w/ ladders & hatch	Yes
11)	Evaluate electronic interference – include Automatic Identification System	**Partial**
12)	Evaluate radar impacts – include blind spots	**Partial**
13)	Evaluate sonar impacts	**No**
14)	Evaluate electromagnetic impact – include navigation compass	**Partial**
15)	Evaluate visual navigation site blocking	**No**
16)	Evaluate acoustic masking – of navigational aids	Yes
17)	Evaluate tidal stream impact	**No**
18)	Evaluate siltation changes	**No**
19)	Evaluate wind mask & shear – on nearby vessels	**No**
20)	Evaluate impact of ice buildup	**Partial**
21)	Evaluate and propose vessel mitigation & protective measures– see detailed MCA Annex*	**No**
22)	Propose vessel safety zones &/or safe operating distances – MCA Annex * has risk class of sites: "High/Med/Low" risk	**No**

Notes: * Refer to Appendix E

** Refer to Appendix B

*** ESS Group... Assessment dated 8/18/03

This comparison revealed that Cape Wind's assessment would have satisfied a few of the MCA and US Coast Guard requirements. However, the assessment would have failed to meet or only partially satisfied the majority of the MCA standards and US Coast Guard requirements.

The sections that follow discuss the results of the above comparison where Cape Wind's assessment appears at variance to the UK MCA standard or to USCG requirements, or both.

Marine Traffic

This report identifies new marine and waterway traffic, routes and density information for Nantucket Sound that was not reflected in the Cape Wind assessment. Specifically, commercial ships were identified as users of the Main Channel in Nantucket Sound that were both greater in number and in size than those considered by the Cape Wind assessment. The significance of these data is to increase both the vessel traffic and the threat of collision and pollution beyond that examined in the Cape Wind risk assessment.

Traffic Survey and Density

The following vessels, missing from the Cape Wind assessment, were recently identified as entering Nantucket Sound and using the Main Channel to transit the length of the Sound (in the case of the offshore fishing fleet from New Bedford) or to transit to Vineyard Sound from Nantucket (in the case of the cruise ships):

Table 4. Recently Identified Vessels Using Nantucket Sound's Main Channel

Vessel Name	Type	Length	Beam	Draft	GT/DWT ***	Max Speed	Cargo
LONE RANGER	Yacht	254′	43′	18.5′	1890	Not known	Not known
CLIPPER ADVENTURER	Cruise	330′	53.5′	15.5′	4,364	14 kts.	122 persons
YORKTOWN CLIPPER	Cruise	257′	43′	8′	976	Not known	Not known
GRAND CARIBE	Cruise	183′	40′	6.5′	761 (ITC*)	Not known	100 persons
GREAT GULL	Tanker	276′	55′	16.6′ (Depth)	1,729	Not known	30,000 barrels
Various (200 – 250) boats fm New Bedford	Comm. Fishing	60-110′	Var**	Var	Var	Var	Fish
Estimate (70) boats fm various fish ports	Comm. Fishing	30 – 60′	Var	Var	Var	Var	Fish

Note: * International Tonnage Convention
** Var = Various dimensions
*** GT/DWT = Gross Tonnage/Deadweight Tonnage

There are several important issues associated with these newly identified vessels as well as others that the Cape Wind assessment did identify. The first and most obvious issue is that a larger number of vessels present within or adjacent to the wind farm facility significantly increase the chance of vessel collision(s) with a wind turbine generator structure.

The size of the above listed larger cruise vessels, yacht and tanker all exceed the size of the vessel (M/V EAGLE) that the Cape Wind assessment chose as a worse case "model" for collision incidents. The Ship Impact Analysis is a critical step in validating the structural design for the sixteen-foot diameter wind tower base. For an unknown reason, the Cape Wind assessment identified another vessel (M/V ATLANTIS) whose size also exceeds that of the EAGLE, yet failed to use the larger ATLANTIS as the worst case for ship impact. The ship impact analysis concern is further discussed under Collision Consequence below.

Fishing vessel transits also deserve close attention for since the position of the wind farm approaches to within 500 yards of the "Main Channel." The last two rows in Table 4 are representative of the fishing vessels that populate Nantucket Sound including those that transit to offshore fishing grounds and those that fish in the Sound proper. An estimated two hundred to two hundred and fifty commercial fishing vessels regularly transit the Sound and use the "Main Channel." An additional seventy or more vessels fish in Nantucket Sound. Identifying the specific characteristics of these vessels is difficult due to the independence and mobility of fishing activity and practice.

Marine Traffic Routes and Density

The Cape Wind navigation risk assessment placed emphasis on the ferries that operate year-round and whose routes pass in close proximity to the wind farm. Other vessels, smaller than the ferry EAGLE, were legitimately dismissed from the risk analysis as presenting a less severe case than modeled by the EAGLE for collision incidents. Still other vessels, larger than the ferry EAGLE were dismissed from detailed analysis based on the erroneous assumption that their deeper draft would lead to grounding before they could strike the base of a wind tower.

There are two valid approaches in defining a marine traffic profile to submit to subsequent navigation risk analysis. The first is to use a detailed statistical method as presented by the authors discussed in the earlier "Best Practice" examples (refer to Appendices F and G).

An alternate approach would be to develop a conservative marine traffic profile based on the capacity and capability of the waterway or route under consideration. As an example, the Main Channel that the wind farm abuts has a controlling depth of thirty feet. It, or specifically Cross Rip Shoal, was first designated as a Federal navigation project at that depth in 1930. The ACOE has continued to maintain that designation for Cross Rip Shoal qualifying the channel for federal maintenance using public funds. The US Coast Guard has maintained the navigational aids along the Main Channel and its connecting arteries to Vineyard Sound and to the ocean through Great Round Shoal channel and Pollock Rip channel. The USCG Waterway Analysis and Management System (WAMS) is a national process administered by each CG region or district to analyze and review the aids to navigation in the nation's waterways. The most recent WAMS study for Nantucket Sound describes its waters, as follows:

> "*The main thoroughfare through the Sound is Nantucket Sound Main Channel. ... This Environmentally and Navigationally Critical waterway hosts ... recreational vessels ... numerous deep draft cruise ships ... and commercial fishing vessels & passenger ferries year round. The majority of Cape Cod and the Islands' recreational ports access Nantucket Sound resulting in severe vessel congestion during summer months. In the event that the Cape Cod Canal is closed due to ice, fog or marine incident, Nantucket Sound is the primary route, along with Martha's Vineyard Sound, that vessels use to transit around the Cape.*" [9] (emphasis added)

Note: The Coast Guard assigns the criticality of U.S. waterways under one of several categories: Non-critical, Militarily Critical, Environmentally Critical and Navigationally critical[10]. As recorded above, Nantucket Sound has been assigned criticality designations under both the Environmental as well as Navigation categories.

The Main channel's capacity is for large ships with drafts up to thirty feet. The channel's capability is not only to serve Nantucket Sound traffic but (as described in the CG WAMS analysis[9]) also to provide an alternate shipping transit lane around Cape Cod in times of very severe weather or emergency. A conservative approach in defining a marine traffic profile would be to choose a vessel with a draft of thirty feet as the "model" or worst-case vessel. Representative dimensions and tonnage could be assigned to this worst-case vessel for submission to a navigation risk and impact analysis. The result would be a wind farm structure designed to withstand the largest vessel the waterways could carry accompanied by mitigation measures designed to accommodate that vessel.

There are approaches other than the above-described methods for determining and applying marine traffic data for a risk assessment and impact analysis. Whatever the approach selected, determining the marine traffic profile is the critical first step to any subsequent analysis. To proceed with the design of a wind farm without accounting for and applying an accurate traffic profile can result in building "bottle-necks" into the marine transportation system or designing substandard wind farm structures, or both.

Nantucket Sound as a Marine Traffic Route
As mentioned earlier the Coast Guard WAMS process has categorized the main waters of Nantucket Sound as both Navigationally Critical and Environmentally Critical. The gravity of these designations is suggested by their definitions. These terms are defined as follows:

> *"Navigationally Critical Waterways (CN). Waterways where a degradation of the aids to navigation system would result in an unacceptable level of risk of a marine accident affecting the national economy due to the physical characteristics of the waterway, difficult navigational conditions, aid establishment difficulties, or high aid discrepancy rates*
>
> *Environmentally Critical Waterways (CE). Environmentally Critical Waterways are waterways where a degradation of the aids to navigation system would present either an unacceptable level of risk to the general public, or to sensitive environmental areas, because of the transport of hazardous materials or dangerous cargoes (such as LNG, chemicals or explosives)"* [10]

Risk Assessment Process

This review of the Cape Wind navigation risk assessment revealed that it did not apply a methodology or practice that determined the frequency of collisions in an analytical way. It does not appear that Cape Wind's methodology applied either the principles or the concepts described earlier in the "Best Practices." Cape Wind's assessment fails to examine or acknowledge the actual marine casualty history of vessels transiting Nantucket Sound. Please see below for the results of our casualty investigation. Finally, no examples were found of an operating or planned wind farm in Europe that located the proposed facility directly adjacent to active shipping channels. While the assessment used depth limitations to mitigate collisions from large vessels through groundings, this use may not accurately reflect the conditions of the channels or of the waters surrounding the wind energy facility's proposed location. There is no barrier based upon the waterway's capacity or from an examination of its depth profile[11], given the wind farm's proposed location, which would prevent vessels with drafts in the range of 20 feet to 30 feet from leaving the Main Channel at any one of several locations and striking a wind turbine tower.

Similarly, no barrier can be found that would discourage deeper-draft vessels from entering the wind farm's proposed location from the east and striking a tower.

The assessment's model or "worst-case" vessel (EAGLE) has a draft of 10.2 feet and a full load displacement that approaches 1,400 long tons. The Cape Wind assessment's marine traffic survey failed to identify a larger body of vessels that use the proposed wind farm's waters as well as vessels with significantly deeper drafts and significantly larger full load displacements.

Finally, Cape Wind's assessment may overemphasize the safety benefit of common safeguards such as the COLREGS[12] and their burden on vessel operators, of navigation systems and of navigational aids both electronic and physical. As is acknowledged, measured and applied in the "Best Practices" (through the probability factors) marine casualties have and will continue to occur in spite of these safeguards.

The McGowan Group examined the commercial vessel casualty record maintained by the Coast Guard for Nantucket Sound for the previous ten years (1992 –2002). The number of reported casualties to commercial vessels was found to be substantial, with seventy-three instances investigated during the period. When personal casualty and injury reports were eliminated from this record as well as incidents occurring on the far eastern or western reaches of Nantucket Sound, thirty-seven reports of casualties remained that occurred to vessels and their equipment in the main body of the Sound. Of these casualties eleven were found to have occurred within five nautical miles of the boundaries of the proposed wind farm and three of these incidents were collisions within one nautical mile of its boundaries.

There was no use found of wind or fog as aggravating factors in the Cape Wind risk assessment. Both factors are referred to in the USCG WAMS analysis as being significant concerns for the waters of Nantucket Sound[9].

Recent additional vessel casualty incidents in late 2003 and early in 2004 continue to validate the threat that vessel failures pose to the proposed wind farm as well as to vessels themselves should they collide with a wind farm tower structure. Commercial ferries continue to lose power and control and drift from the Hyannis to Nantucket routes and channels potentially into the proposed wind farm location. The ferry FLYING CLOUD suffered just such a failure in both December 2003 and in March 2004. A cargo mishap (LPG tank truck) in January 2004 aboard another ferry, the KATANA, apparently was caused by severe wind and waves. The ferry in returning to Hyannis with the onboard emergency was forced to traverse through the proposed wind farm location driven by the prevailing east to northeast winds.

Collision Consequence

The Cape Wind navigation risk assessment evaluated the consequence of a collision by a vessel, modeled after the ferry EAGLE, against the structural failure limit of a wind turbine tower only. It did not present or explore damage to the colliding vessel or to its cargo.

Given the observations made under "Marine Traffic," described above, the USCG requirement for a detailed analysis of the consequences of vessel collision is valid and should be fully pursued. With the proposed wind energy facility's position adjacent to a deep draft channel and active ferry routes, the consequence to a striking vessel should be examined as well as the consequence to a wind turbine tower structure. These examinations, as driven by collision frequency, should include injury to passengers aboard, as well as holing of a ferry, cruise vessel, fishing vessel and of a large tank vessel carrying heating or fuel oil. The "Best Practice" methodology presented by Randrup-Thomsen et. al in Appendix G readily lends itself to such a vessel damage investigation. Randrup-Thomsen et. al propose the method which could be applied to examine the oil pollution consequence resulting from a collision of a large vessel such as the GREAT GULL with a cargo capacity of 30,000 barrels of fuel oil with a wind turbine tower.

The wind turbine tower structure impact analysis preformed in the Cape Wind assessment, defines and selects a "Utilization Factor" as the measure of tower structural integrity after a collision. According to the Cape Wind assessment, "A Utilization Factor less than 1.0 indicates ability of the tower and foundation structure to sustain impact …"[1] With this definition, a vessel collision that produces a Utilization Factor equal to or greater than 1.0 will cause the tower and blade and/or the tower foundation to fail.

The Cape Wind "worst case" scenario for the striking vessel was the ferry EAGLE that produced a Utilization Factor of 0.95 when its collision with a tower occurred at a speed of twelve knots. Without questioning the specific model used in the assessment for the tower structure, the Cape Wind assessment method suggests that a collision by any one of the larger vessels (i.e. LONE RANGER, CLIPPER ADVENTURER, or GREAT GULL) would produce a Utilization Factor exceeding 1.0. Simply put, any vessel larger than the EAGLE colliding with a tower at twelve knots or higher speed would cause complete failure of the tower and blade and/or its foundation structure. Tower failure caused by a striking cruise vessel or tank vessel could have catastrophic safety and/or pollution consequences far beyond damage to the wind energy facility infrastructure.

Cape Wind's assessment that a vessel would survive a collision with a tower without flooding and sinking is unsubstantiated. Fishing vessel casualties have sadly and consistently demonstrated that a high-energy collision by an older fishing vessel, while causing little tower damage, would likely result in rapid flooding of the engine space and sinking of the vessel (if holed) within a matter of minutes.

Vessel-on-Vessel Collisions

The analysis that the Cape Wind assessment offers for vessel-on-vessel collisions appears misguided. The use of the design standards of the American Association of State Highway and Transportation Officials and of the Engineering Handbook of the Institute of Traffic Engineers to analyze collisions between vessels is baffling. Cape Wind's analysis of high-speed, small boat maneuvering around wind tower bases while interesting, contributes little to a navigation safety risk assessment. Effort would be better spent in an analysis of commercial vessel-on-vessel collisions since this wind energy facility's placement abuts a shipping lane. The Cape Wind project, for a location that has already experienced a history of vessel collisions, may well influence vessels transiting the Main Channel and increase their risk of collision.

The Coast Guard issued a specific requirement (see Appendix B) for the Cape Wind's assessment to perform "An analysis of any increased danger of vessels colliding with each other or grounding due to the installations." This requirement appears designed to generate a close scrutiny of risk to vessels that become "crowded" in their transits by the proposed wind farm installation. The Cape Wind infrastructure will place new obstacles before vessels that formerly traversed unimpeded in the area as well as vessels forced into the area by unfavorable wind, current, ice or emergency condition. Ferry operations, in particular, are reported to be pressured towards or into the proposed wind farm area by easterly and northeasterly winds. The Cape Wind assessment does not contain such an analysis.

Operating Limits and Mitigation & Protection Measures

As indicated earlier, our analysis revealed that Cape Wind's assessment did not apply a methodology or practice that determined the frequency of collision or the risk to the facility in any quantifiable manner. With the exception of traditional navigation aids, there are no recommendations in Cape Wind's navigation risk assessment regarding operating limits and mitigation measures that would apply during the project's design, construction (1½ - 2 years) or operating phases. In sum, the Cape Wind assessment begs the conclusion that the proposed twenty four square mile facility is so benign as to require only navigation lights, some sound signals, new buoys and notations on marine charts. Cape Wind's assessment is that the wind farm poses no added risk to current waterway users and requires no mitigation measures to manage the minimal risks it might face during construction and operation.

Cape Wind's position on navigation risk and minimal mitigation measures stands at strong odds to the international record established at other wind farms. As indicated earlier, existing offshore wind farms employ substantial operating restrictions and mitigation measures strongly impacting waterway users. These same wind farms occupy much smaller water areas, are located in shallower water, operate a greatly reduced number of generator towers and are removed at great distances from shipping lanes when compared to the Cape Wind proposal. Given the importance of these factors to manage the risks identified in a realistic assessment, operating limits and mitigation measures should have been identified and announced at the earliest stages of Cape Wind's energy facility's design.

The most significant design factor that will drive operating limits and mitigation measures in the Cape Wind project is the proposal to locate the wind energy facility directly adjacent to shipping channels and ferry routes. The need for waterway use limits is driven further by the decision to place the wind farm in the center of an area known to be an active fishing ground and the locus of a substantial concentration in recreational boating.

The Cape Wind navigation risk assessment fails to fully account for the following realities that are likely to require mitigation actions to be taken at some point in the wind energy facility's development and operation:

1. Construction of the tower structures along the boundary of the Main Channel in Nantucket Sound may require channel use to be restricted or closed for deep-draft vessels for an extended period of time impeding marine transportation including fuel and supplies to the Nantucket Sound islands.

2. During construction of the wind energy facility, all marine traffic (except for construction vessels) may be restricted from the twenty-four square mile confines of the entire facility;

3. During and after construction trawling or dragging activity by fishing vessels may be prohibited for the life of the project;

4. During and after construction all vessels with mast heights exceeding seventy-four feet may be prohibited from entering the wind energy facility for the life of the project;

5. After construction the wind energy facility may be required to maintain a continuous on-site control room presence with an active radar and radio watch to initiate or pass emergency transmissions, such as an emergency stop order for turbine blades and the transmission of electricity, for the life of the project;

6. After construction or during periods of high vessel activity, the wind energy facility may be required to maintain a continuous radar, radio and or boat guard capability to assist vessels in distress and/or to maintain vigilance over any operational boating restrictions;

7. During and after construction, anchoring may be prohibited within the wind farm boundaries as well as adjacent to the paths of transmission cables for the life of the project to preclude the possibility of large vessels dragging anchor in high winds or in low visibility conditions; and

8. After construction, exclusionary zones may be required throughout the wind farm or around the base of each tower for the life of the project.

Likely Impacts on Waterway Users

Determining the need and type of operational or other mitigating actions depends first upon a marine traffic survey and then upon the results of a risk model to forecast collision frequency.

Fishing Vessels

As recognized in the USCG WAMS[9] study and the Coast Pilot[13], obtaining vessel traffic information and generating a marine traffic profile is particularly difficult for the fishing vessel population that passes through or fishes in Nantucket Sound. Information provided by a variety of sources, including marine surveyors and vessel owners/operators, revealed that up to two hundred-fifty fishing vessels, as indicated in Table 4, routinely transit the length of Nantucket Sound on voyages to and from offshore fishing grounds. In times of bad weather or when making repairs, these vessels also have needed to use the General Anchorages surrounding the proposed wind energy facility location.

The Cape Wind assessment identified eighteen fishing boats and an unspecified number of scallop dragger/herring seiner boats in its traffic survey. Working with knowledgeable, local fishing interests, approximately 70 fishing boats that fish in Nantucket Sound were identified that would be negatively impacted by the proposed wind farm's location.

Acknowledgement of the wind farm's potential impact on this fishery is particularly important since conversations with many of the local fishermen attribute 50 – 60% of their livelihood to fishing Nantucket Sound and the Horseshoe Shoal area. Conversations with these fisherman revealed that the National Marine Fisheries Service recently reduced fishing fleet "days-at-sea" averages by some 40% for groundfish. The result of this action will be to exert increased pressure on the Nantucket Sound fishery as boats that previously fished offshore return to the Sound, in an effort to reduce their days-at-sea to the new limits.

The typical profile of vessels that fish in the Sound, and specifically in and around the vicinity of Horseshoe Shoal is:

- Vessel size: 30 feet – 72 feet;
- Gear/method used: Bottom otter trawl, Scottish seine, Scallop dredge, Clam dredge, Pots & traps and Mid-water trawls;
- Catch: Scup/Porgie, Squid, Striped Bass, Bluefish, Atlantic Bonito, Butterfish, Clam/Quahog, Flatfish, Summer & Winter Flounder, Lobster, Atlantic Mackerel, Black Sea Bass, Skate, Tautog, Atlantic Herring, Conch.

A significant number of the boats are homeported in the Sound's main fishing ports: Chatham, Harwich, Hyannis, Falmouth, Nantucket and Martha's Vineyard[14]. Others hail from Point Judith, RI to Cape Elizabeth, ME and travel the distance to follow the catch. All who drag or trawl for their catch will be impacted by the construction and operation of the wind farm on this active fishing ground. The Cape Wind assessment is silent about future fishing activity within or adjacent to the wind energy facility.

Given the restrictions on fishing activities commonly imposed at the majority of existing European wind energy facilities, the likelihood of similar restrictions being imposed at Cape Wind facility is high. Internationally, restrictions on fishing commonly apply to dragging, trawling, and anchoring. The majority of the boats trawling/dragging in Nantucket Sound employ the following techniques at the indicated gear length behind their boat:

- Bottom otter trawl – 200 - 600 feet with an attached dredge

- Scottish seine – two miles of line with attached net covering an area up to ½ square mile

- Hydraulic quahog/clam dredge – seventy- five feet of cable and hose with attached dredge

Using these techniques, the proposed 0.34 nautical miles minimum separation between towers, or the alley that vessels could navigate shrinks to 1,720 feet if a typical fifty-meter exclusion or safety zone is imposed around each structure's base. Imposing a fifty-meter zone has become standard practice at existing wind energy facilities and is mentioned in the UK's MCA standards for even medium risk wind energy facilities. Given the length of trawl, the practice of following bottom contours, the wind and current conditions in Nantucket Sound, as well as the basic navigating methods employed by most older fishing vessels, this shrinkage will effectively eliminate all trawling/dragging within the entire confines of the wind farm.

While the exact catch or the value of the Nantucket Sound fishery has not been determined. The value caught, for species inhabiting Nantucket Sound, was approximately $280,000,000 [14] in 2001 for the state of Massachusetts. It is certain that the Nantucket Sound fisheries portion of the catch represents a significant share of the 109,000 metric tons total caught that year as well as of its value. Fishermen that ply Nantucket Sound are clearly heavily invested in the fishery. The Nantucket Sound fishery makes a substantial contribution to the state's fishery and to the region.

Recreational Vessels

The vessel height analysis presented in the Cape Wind assessment, as well as the comments in the Coast Guard's review letter (Appendix C), were both evaluated. Once again the concern arose with the assessment's selection of the ferry EAGLE as a worst-case scenario, similar to the concern identified in the previous section on vessel collisions and ship impact analysis. In this instance the EAGLE, again selected as the assessment's worst-case, is not the vessel with the greatest mast height utilizing Nantucket Sound.

The Cape Wind assessment examined the mast height for recreational boats up to sixty-five feet in length but, for some unknown reason, not for recreation, yacht or sailing vessels longer than sixty-five feet in length. Cruise vessels, yachts or large sailing vessels with mast heights exceeding seventy-five feet face the greatest danger of being struck by a rotating wind turbine blade if they were to enter the circumference of the blade sweep. All vessels in a marine traffic survey should be examined for mast height. Mitigation action should then be identified and proposed to address the danger faced by vessels with large mast heights.

This is more than an academic exercise for the waters of the proposed wind energy facility. Discussions with harbormasters and marina interests in close proximity to the central portion of the Sound estimate that as many as seventy-five to one hundred boats (with lengths greater than sixty-five feet and mast heights exceeding seventy-five feet) visit the central portion of the Sound during the summer season.

This issue demands closer examination to identify the full risk to "tall" vessels and propose appropriate mitigating action. The actions contained in the United Kingdom's MCA standards regarding emergency procedures for monitoring, controlling and stopping the turbine blades are helpful. They may however, need to be expanded for a Nantucket Sound location. Outright exclusion of all vessels with large mast heights may be necessary for the life of the Cape Wind project. A live radio "watch," a radar system monitored by the wind energy facility operator, an emergency communication system and security boats operated by the wind farm may also need to be employed to ward off or to respond to vessels with large heights of mast.

Anchoring Vessels

The Cape Wind assessment examined the ability of vessels to anchor in and around the wind park after construction, and concluded that no restrictions to anchoring would be needed. This conclusion was reached based on an examination of fluke depth penetration for different anchors (4.5 feet for the EAGLE) and compared favorably to the depth to which cables will be buried (6 feet) within the boundaries of the facility. While this outcome may sound favorable for vessel operations in the area, it is at odds with the anchoring restrictions encountered at many of the operating, international offshore wind farm locations. Anchoring in high, variable current areas within or adjacent to the wind farm may also increase the risk of anchor strike to a submarine cable.

Cape Wind's assessment proposes burying the cables to a depth of six feet below the Sound's seabed. At this cable depth, one and one-half feet of covering material will be left as a safety margin below which anchors, such as carried by the ferry EAGLE and MARTHA'S VINEYARD, are not predicted to penetrate. Given that anchorages surrounding the proposed wind farm have water depths up to sixty feet, the Cape Wind proposal represents a mere 2.5% safety margin at those depths. This safety margin could quickly disappear due to bottom scouring action of the present current patterns or due to changes in siltation and bottom sediment transport induced by the introduction of new marine substructures in the area. Shallow installation of cable, scouring of the bottom, or sediment transport of the seabed induced by wind tower structures could expose anchoring vessels to an increased risk of striking wind farm submarine cables. Please also refer to the Environmental Influence section below.

It appears that the Cape Wind conclusion regarding anchoring was reached without examining the impact of vessel anchoring maneuvers on collision frequency. Vessels maneuvering to or from anchorage face an increased risk or losing power, steerage and control. Vessels at anchor face an increased risk of dragging anchor in high current areas, during severe weather or when improperly attended. Anchorages or anchoring operations in areas adjacent to wind farms increases the risk of damage to wind farm structures and vessels alike. Permitting anchorages in high current areas may also raise the risk of uncovering a buried submarine cable.

The wind energy facility location proposed by Cape Wind is virtually surrounded by the general anchorages "I", "G","H", and "J" indicated on maritime charts and described in the Coast Pilot.[11, 13] While smaller vessels may pose reduced risk of damage to the wind farm infrastructure, substantial risk of harm and damage is posed by the tower structures to these vessels. Anchoring restrictions need to be examined in the context of mitigating damage to vessels either in colliding with a wind tower or being struck by a turning wind turbine blade as discussed under Recreational Vessels above.

The mitigation actions discussed in the previous section restricting anchoring are consistent with the practices followed at other wind energy facilities in international locations. Little stock can be placed in the "wide" 640-yard by 1080-yard spacing between towers or the premise that boats and ships can steer in straight lines between the rows of towers. Experience in marine casualty investigation has demonstrated that straight course lines or intentions can be instantaneously erased when a mechanical failure occurs, or when wind, wave, current or poor visibility adversely affect vessel navigation. While 130 towers may help troubled mariners and boaters report their location and rescue forces to better plot their search and response, immovable concrete and steel structures in any waterway remain obstructions and increase the likelihood and potentially disastrous consequences of casualties to vessels.

Electronic Interference

The Cape Wind assessment also identifies expected impacts to various electronic equipment and systems. Each area addressed by Cape Wind is reviewed below:

Radar and Sonar Systems

Cape Wind's assessment offers results of actual shipboard tests of surface search radar reported from observations taken at the Horns Rev wind energy facility with no negative impacts reported. No information is offered with regard to the impact on surface to air radar or Air Traffic Control (ATC) radar systems. Media accounts in the previous year have reported land based wind farm interference with both military (surface to air) and ATC radar.[15] This reported interference should be brought to the attention of the FAA, FCC and the appropriate elements within DOD.

No mention is made or assessment offered regarding the proposed wind energy facility's impact on Sonar systems. The USCG did not require the assessment of this impact. This issue should be called to the attention of the appropriate elements of DOD.

Electronic Communication and Positioning Systems

The Cape Wind assessment offers the results of actual shipboard tests of VHF radio systems reported from observations taken at the Horns Rev wind energy facility with no negative impacts reported. No mention is made or assessment offered regarding the proposed wind energy facility's impact on UHF, Microwave communication systems or television systems. Recent studies of land based wind energy facilities and prior research by the International Telecommunications Union indicate that wind towers and turbine blades may obstruct or interfere with signals in the UHF, microwave and TV ranges.[16] This issue should be brought to the attention of the FAA, FCC and the appropriate elements within DOD.

Cape Wind's assessment offers the results of on-scene acoustic tests reported from background "noise" measurements taken from a small boat in the vicinity of the proposed wind farm with no negative impact reported. Noise levels produced by the wind turbine generators are predicted to fall below the ambient noise levels measured on Nantucket Sound.

Cape Wind's assessment also explains that the inner array of connecting electrical cables among the wind turbine generator towers as well as the submarine cables connecting the facility to land should produce no negative impact on positioning systems including a magnetic compass. However, the assessment is silent on the potential electromagnetic impact of the wind turbine generators and/or structures on other vessel positioning systems such as the maritime Differential Global Positioning Service (DGPS). This issue should be brought to the attention of the USCG, FAA and FCC.

Visual Navigation

No mention is made or assessment offered regarding the proposed wind farm's impact on visual sight navigation. The USCG did not require the assessment of this impact. Traditional navigation methods practiced on the Sound among recreational, fishing and racing interests rely heavily upon "line of sight" navigation and the ability to distinguish landmarks during both day and night. The presence of so many structures and associated navigation lights may seriously inhibit this type of navigation particularly for the large number of commercial fishing vessels known to actively fish or transit the area. This issue should be brought to the attention of the USCG.

Environmental Influences and Impact

The USCG did not require an assessment of changes to tide, wind, or siltation that may be driven by the proposed wind farm as part of the Cape Wind navigational assessment.

The Coast Pilot[13] singles out Nantucket Sound especially in the area from Cross Rip Shoal to Hedge Fence Shoal (approximately 4 nautical miles west of the proposed wind farm boundary) for special caution due to high velocity currents (2.5 knots) that occur particularly during storms. As mentioned earlier in the Anchoring Vessels section, high, variable bottom currents raise the question of bottom sediment transport and its impact on anchoring risk. High bottom currents also bring into question the impact of sediment transport induced by new wind farm submarine structures. The Cape Wind assessment also fails to explore sediment transport and its potential impact on wind farm substructure stability.

The Coast Guard required an evaluation of ice buildup on navigation. Cape Wind's assessment concerning ice provided anecdotal information only based on limited, informal observations in February 2003 without commenting directly on the impact to the "Main Channel".

The 2003/2004 winter brought severe and sustained cold weather to the Nantucket Sound area. It was reported that temperature and ice conditions in the Sound were among the worst observed in over a hundred years. Ice clogged and closed the channels on several occasions repeatedly interrupting ferry operations. The Coast Guard mounted and sustained ice-breaking operations and eventually had to reset buoys that had been moved off of their stations by ice cover and floes.

It should also be noted that the draft Det Norske Veritas standards for offshore wind turbine structures include extensive requirements and guidelines for the calculation of minimum ice loads on these structures including those located in sheltered coastal waters.[8]

Oil Pollution

The USCG did not specifically require Cape Wind's assessment to cover the likelihood, frequency, size and results of a marine environmental pollution incident from a vessel collision with a wind tower. The CG did require an evaluation of the "... likely consequences of a collision (What-if) analysis" (see Appendix B) that could include the impact of marine pollution resulting from a collision. The international "Best Practice" described in Appendix G substantiates that the examination of oil pollution potential as a result of a vessel/wind tower collision is part of the vessel consequence process.

The McGowan Group examined the marine pollution record maintained by the Coast Guard for Nantucket Sound for the previous ten years (1992 –2003). The number of pollution incidents reported and investigated during the period was fifty-six cases. Land-based incidents, cases that could not be linked to a specific vessel, as well as cases occurring on the far reaches of Nantucket Sound or in its harbors were eliminated from further consideration. Additionally small pollution incidents (with a potential spill equal to or less than 5 gals.) were ignored for the purpose of this analysis. Twelve reports of marine pollution remained that resulted from vessels in the main body of the Sound. Of these twelve pollution incidents, two were found to have occurred within five nautical miles of the boundaries of the proposed wind farm.

The expediency for examining the potential for oil pollution effects is heightened due to the known oil product traffic that routinely passes the proposed wind farm boundaries. Pollution potential is of heightened concern with the passage of a large tank vessel (e.g. GREAT GULL) carrying a total fuel oil capacity approaching 1.3 million gallons, which uses the Main Channel directly adjacent to the proposed wind farm.

Final Note

It must be noted that the draft standards for the design of offshore wind turbine structures recently issued by Det Norske Veritas (DNV) provide detailed requirements covering the need for investigating ship impacts and collisions.[8] Specifically, these pending DNV requirements call for the following elements in a collision risk analysis for "offshore wind farms located in waters with commercial ship traffic":

- An investigation of ship traffic identifying shipping lanes, annual traffic, and ship types and sizes for each lane;
- Wind, waves, current, ice and visibility, to be included in the calculation of <u>collision frequency</u> (emphasis added);

- Evaluation of collision frequency involving navigational error, a mechanically disabled ship, and a steering failure for wind farms located very close to shipping lanes;
- Evaluation of the consequences of the different scenarios such as structural safety (e.g. damage of wind turbine, support structure and ship), human safety (e.g. injuries and fatalities) and the environment (e.g. an oil spill) (emphasis added);
- Calculation of risk for each scenario;
- Evaluation of whether total risk from all scenarios is acceptable. If no risk acceptance criteria are given, then the calculated total risk should be compared with risks accepted at other offshore wind farm locations;
- Recommendation of cost-effective or necessary risk reduction measures (emphasis added); and
- Final risk should be verified against historical data of ship collisions and groundings (emphasis added).

Sound's Main Channel. These alternative sites therefore face similar risks and pose the same potential disruption of marine traffic, as does the Horseshoe Shoal location.

6. There is a substantial discrepancy between common international practice and the minimal mitigation measures for navigation issues proposed by the Cape Wind assessment. Cape Wind proposes navigational lighting, sound signals, private aids, markings and notations on charts as the only safety features to offset the risks posed by the new energy facility to current shipping, boating and fishing interests. International practice has employed total or partial exclusion of selected groups, or, in some cases, all marine traffic, and outright prohibition on trawl fishing or anchoring in proximity to the offshore wind farm areas. The United Kingdom standards (Appendix E) recommend an additional mix of safety measures for "higher risk" facilities including:
   - *Safety zones up to 50 meters*
   - *Monitoring by radar, Automatic Identification System transponders*
   - *Continuous watch by multi-channel VHF radio*
   - *Use of guardship or guardships*
   - *Declaration of "Area to be Avoided" (ATBA) around the whole wind farm and up to 500 meters from the extremities*
   - *Continuous vessel monitoring/information service using radar*
   - *Closure of nearby shipping routes where there are suitable alternatives*

7. The Cape Wind navigation safety risk assessment and Nantucket Sound project proposal is fatally flawed due to its failure to:
   - Develop and apply design criteria showing that placement of the proposed wind energy facility adjacent to active shipping channels is compatible with the needs of marine transportation, and poses necessary and reasonable risks to cruise ship and ferry vessel, oil transport, fishing and recreational users.
   - Propose a tower structure whose strength was sufficient to withstand a collision without complete failure of the tower and blade and/or the tower foundation;
   - Utilize recognized methodology or to perform a complete risk assessment by examining and predicting collision frequency calibrated against actual marine casualty and marine pollution histories;
   - Conduct an accurate measure of the types, routes, and density of the current marine users of the waters of Nantucket Sound;
   - Assess the safety and pollution consequences, including injury and loss of life, resulting from vessel collisions with a wind tower;
   - Consider the aggravating effects of wind, fog, and current on safe navigation;

- Recognize the inherent risk of vessel collisions in a realistic manner, without overemphasizing common safeguards such as the COLREGS[12] and their burden on vessel operators, or navigation systems and/or of navigational aids;
- Identify and propose realistic "best practice" mitigation measures to offset the safety and environmental risks identified;
- Explore the negative impact to the Nantucket Sound fishing industry by acknowledging that these projects will effectively cut-off all trawling/dragging within the entire confines of the wind farm; and
- Highlight the threat the wind turbine blades pose to a substantial number of sailing or other vessels (including cruise vessels) with mast heights exceeding seventy-five feet.

8. The USCG navigation risk assessment requirements for the Cape Wind project (Appendix B) recommended that the FAA and FCC be informed and included in evaluation of the potential electronic interference from the wind energy facility. The scope of the electronic investigation should be expanded to include UHF, Microwave and TV communication and navigation frequencies. The electronic assessment information to be presented in the DEIS/DEIR should also include the electromagnetic impact of the tower generators and tower structures on vessel positioning systems.

9. The navigation and structural strength impacts due to ice build-up in the Main and adjacent channels and around the wind towers adjacent to the Main Channel and environmental assessment factors including the effects of tide, wind, current, and scouring of bottom sediments should be fully examined.

10. The pollution consequences of vessel-to-vessel and vessel-to-wind tower collisions must be fully explored as part of the USCG navigation assessment (Appendix B), as contained in international "Best Practice" (Appendix G) and as proposed by the pending Det Norske Veritas standards.[8]

11. The Coast Guard should consider, prior to any decision regarding the pending EIS, evaluating the impact of maritime security mitigation measures for the Cape Wind proposals on the marine transportation system in Nantucket Sound.

REFERENCES

[1] ESS Group, Inc. "Navigation Risk Assessment, Cape Wind Project, Nantucket Sound," Project No. E159-004.8, August 18, 2003

[2] Commonwealth of Massachusetts, Executive Office of Environmental Affairs, Certificate of the Secretary of Environmental Affairs on the Environmental Notification Form dated April 22, 2002

[3] Peer Review Committee, Offshore Wind Energy, New England Technical Review of Preliminary Screening Criteria for the Cape Wind EIS. Consolidated comments on Section 2.0 and 3.0 of the Draft EIS, 9/30/03

[4] UK Department of Trade and Industry Report, "Energy White Paper, Our energy future – creating a low carbon economy," February 2003

[5] UK Department of Trade and Industry Report, "Future Offshore – A Strategic Framework for the Offshore Wind Industry," November 2002

[6] The Crown Estate; http://www.thecrownestate.co.uk/

[7] Thomas Edwards, Frazer McCallum, "Robin Rigg Offshore Wind Farm (Navigation and Fishing) (Scotland) Bill; SPICe Briefing, 02/88, 15 August 2002

[8] "Design of Offshore Wind Turbine Structures," Offshore Standard DNV-OS-J101, Det Norske Veritas, Draft, January 2004

[9] Waterways Analysis and Management Survey of Nantucket Sound Main Channel, Pollock Rip Channel and Great Round Shoal Channel, USCGC BITTERSWEET (WLB-389), 10 Oct 96

[10] USCG Commandant's Instruction, "Waterway Analysis and Management System," 16500.11B dated 18 March 1987

[11] NOAA Chart, 13227, Nantucket Sound and Approaches

[12] International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS)

[13] U.S. Coast Pilot, Atlantic Coast: Cape Cod, MA to Sandy Hook, NJ, 2003; DOC- NOAA

[14] NOAA Fisheries, Office of Science & Technology, Fisheries Statistics & Economic Division, Commercial Fisheries, htto://www.st.nmfs.gov/st1

[15] BBC News report, "Wind farm blow to radar systems," January 28, 2003; 16:46 GMT

[16] BCL report, "Radio Interference Analysis – Manawatu Gorge Wind Farm," 02 May, 2003

APPENDICES

BILLING CODE: 3710-24

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Intent to Prepare A Draft Environmental Impact Statement (DEIS) for Proposed Cape Wind Energy Project, Nantucket Sound and Yarmouth, Massachusetts, Application for Corps Section 10/404 Individual Permit

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: The New England District, Corps of Engineers, has received an application from Cape Wind Associates, LLC for a Section 10/404 Individual Permit for the installation and operation of 170 offshore Wind Turbine Generators (WTGs) in federal waters off the coast of Massachusetts on Horseshoe Shoal in Nantucket Sound, with the transmission lines going through Massachusetts state waters. The Corps has determined that an EIS is required for this proposed project, currently the first proposal of its kind in the United States. The applicant's stated purpose of the project is to generate up to 420 MW of renewable energy that will be distributed to the New England regional power grid, including Cape Cod and the islands of Martha's Vineyard and Nantucket. The power will be transmitted to shore via a submarine cable system consisting of two 115kV lines to a landfall site in Yarmouth, Massachusetts. The submarine cable system will then interconnect with an underground overland cable system,

Appendix A-1

where it will interconnect with an existing NSTAR 115kV electric transmission line for distribution.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and DEIS can be answered by Mr. Brian Valiton, Regulatory Division, U.S. Army Corps of Engineers, 696 Virginia Road, Concord, Massachusetts 01742-2751, Telephone No. (978) 318-8166, or by e-mail at brian.e.valiton@usace.army.mil.

SUPPLEMENTAL INFORMATION: The proposed wind turbine array would occupy approximately 28 square miles in an area of Nantucket Sound known as Horseshoe Shoals between Nantucket Island and the Cape Cod mainland. The northernmost turbines would be approximately 4.1 miles from the nearest land mass (Point Gammon), the southeastern most turbines would be approximately 11 miles from Nantucket, and the westernmost turbines will be approximately 5.5 miles from Martha's Vineyard. The array of generators was established in a northwest to southeast alignment to provide optimum utilization of the wind energy potential. The proposed submarine cable landfall location is Yarmouth, Massachusetts. Each wind power generating structure would generate up to 2.7 megawatts of electricity and would be up to 420 feet above the water surface. The proposed submarine cable system, consisting of two 115 kV solid dielectric cable circuits, would be jet-plow embedded into the seabed to a depth of approximately 6 feet. The foundations of the WTG's may require scour protection. Scour protection would require the placement of stone riprap or concrete matting on the seabed surface surrounding the foundation. The

1972, as amended (Pub. L. 92-583; 16 U.S.C. 1451, *et seq.*); and the Clean Water Act of 1977, as amended (Pub. L. 92-500; 33 U.S.C. 1251, *et seq.*), Section 10 of the Rivers and Harbors Act of 1899, 33 U.S.C. 403 *et seq.)*; the Outer Continental Shelf Lands Act (Pub. L. 95-372; 43 U.S.C. 1333(e)), and applicable and appropriate Executive Orders. Additionally, this EIS will be prepared concurrently with the requirements of the Massachusetts Environmental Policy Act (301 CMR 11.00 *et seq.).*

Scoping: The Corps will conduct an open scoping and public involvement process during the development of the EIS. The purpose of the scoping meetings is to assist the Corps in defining the issues that will be evaluated in the EIS. Scoping meetings will be held on March 6, 2002 starting at 1:30 pm at the JFK Federal Building, 55 New Sudbury St., Conference Room C, Boston, Massachusetts, and on March 7, 2002 starting at 6:30 pm at the Mattacheese Middle School, 400 Higgins Crowell Rd., West Yarmouth, Massachusetts. All interested Federal, State and local agencies, affected Indian tribes, interested private and public organizations, and individuals are invited to attend these scoping meetings.

The Draft EIS is anticipated to be available for public review in the summer of 2003.

BRIAN E. OSTERNDORF

COL, EN

Commander

U.S. Department of Transportation

United States Coast Guard

Commanding Officer
U. S. Coast Guard
Marine Safety Office

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16670
February 10, 2003

Karen K. Adams
Chief, Permits and Enforcement Section
Department of the Army
Corps of Engineers – New England District
696 Virginia Road
Concord, MA 01742-2751

Dear Ms. Adams:

Enclosed are a variety of analyses that we are requiring to be included in the Environmental Impact Statement (EIS) for the Cape Wind Energy Project in Nantucket Sound. We have included analysis requirements regarding the project's potential impact on navigational safety and also on search and rescue operations, communications, radar, and positioning systems. In addition to these analyses, any structures built will be required to meet Coast Guard regulations for marking as private aids to navigation.

We are prepared to review and comment on the completed assessments and on other marine navigation related information associated with the preparation of the EIS. We are not, however, in a position to undertake data collection, conduct EIS analyses, or prepare sections of the draft or final EIS as staff and resources are fully tasked in other obligatory programs. However, we understand that the Coast Guard will be the source agency for some of the data required for the assessments and we will provide the data under routine methods upon request of the developer.

We recommend that you forward sections 2 and 3 of the enclosure to the Federal Aviation Administration and section 3 to the Federal Communications Commission as these areas of concern are also within their purview.

If you have any questions, please contact the Coast Guard project POC, Mr. Peter Popko at (401) 435-2380 or ppopko@msoprov.uscg.mil.

Sincerely,

Mary E. Landry

Mary E. Landry
Captain, U.S. Coast Guard
Captain of the Port

Enclosure: Cape Wind – Nantucket Sound - Assessment Elements

Appendix B-1

CAPE WIND – NANTUCKET SOUND – Assessment Elements

1. Navigational Safety:

The Cape Wind – Nantucket Sound project developers must conduct a navigational safety risk assessment as part of the Environmental Impact Statement. The assessment must include, but is not limited to, the following elements:

a. A marine traffic survey in proximity to the proposed locations that includes:

- Types, sizes, and drafts of vessels.
- Typical routes.
- Density of traffic.
- Seasonal variances in traffic.
- Marine events.

b. An analysis of expected weather conditions, current directions/velocities, water depths and sea states that might aggravate or mitigate the likelihood of collision with the towers and navigational safety in general.

c. An evaluation of the risk of collision between vessels and the towers that includes:

- Likely frequency of collision.
- Likely consequences of collision ("What- If" analysis).
- The ability of a tower to withstand collision damage without toppling for a range of vessel speeds and vessel sizes.

d. An analysis of any likely changes in vessel movements resulting from the installations.

e. An analysis of any constraints imposed by the installations upon local navigation and anchoring.

f. An analysis of any increased danger of vessels colliding with each other or grounding due to the installations.

g. An analysis of the likelihood of floating ice build-up around and between the towers, and its possible impact on vessel navigation.

h. An analysis and discussion of the impact on the ability of all classes of vessels to anchor within the vicinity of the tower field.

2. Search & Rescue

Coast Guard opinion: Searches for small vessels or people in the water (PIW) and smaller search objects will be particularly affected due to the higher helicopter and fixed wing search altitudes required. The probability of detecting these targets will be decreased due to the presence of the wind farm. Additionally, the presence of the towers and their rotating blades will significantly diminish the ability to hoist victims by helicopter in the area of the wind farm.

To gauge the potential extent of impact on search and rescue operations, the Cape Wind – Nantucket Sound project developers must conduct an assessment that includes, but is not limited to, the following elements:

a. How many search and rescue cases has the CG conducted in the Horseshoe Shoals region over the last ten years?

b. How many of these cases involved helicopter hoists?

c. How many were at night or in poor visibility/low ceiling?

d. How many of these cases involved helicopter searches?

e. How many times have commercial salvors (e.g., BOAT US, SEATOW, commercial tugs) responded to assist vessels in the Horseshoe Shoals region over the last ten years?

f. How many were at night or in poor visibility?

g. What number of additional SAR cases is projected due to allisions with the towers?

3. Communications, Radar and Positioning Systems:

To gauge the potential extent of impact on communications, radar and positioning systems, the Cape Wind – Nantucket Sound project developers must provide researched opinion concerning whether or not:

a. The generators and their mountings could produce radio interference such as reflections or phase changes, with respect to any frequencies used for marine positioning, navigation or communications, including VHF radio, Radio Direction Finding equipment, and Automatic Identification Systems.

b. The generators could produce radar reflections, blind spots or shadow areas:

- Vessel to vessel.
- Vessel to shore.
- Racon (radar beacon) to / from vessel.

c. The generators, in general, would comply with current recommendations concerning electromagnetic interference.

d. The site might produce acoustic noise that could mask prescribed navigational sound signals.

e. The generators and the seabed cabling might produce magnetic fields affecting compasses and other navigation systems.

U.S. Department of Homeland Security

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16670
July 31, 2003

Karen K. Adams
Chief, Permit and Enforcement Section
Department of the Army
Corps of Engineers - New England District
696 Virginia Road
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Dear Ms. Adams:

Thank you for permitting Coast Guard Marine Safety Office (MSO) Providence to review the draft Navigational Risk Assessment, Cape Wind Project, Nantucket Sound, prepared by ESS Group, Inc., dated June 24, 2003. It appears to have sufficiently addressed the issues raised in MSO Providence's letter to you of February 10, 2003. I would recommend the following two items be addressed:

1. In section 4.3.2 of the Assessment, "Navigation Rules" recommend that the following be inserted:

    - Rule 5, "Look-out" states that "Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

2. An issue that may require clarification is blade clearance over vessels that may come within 22 feet of a wind turbine generator (WTG) tower. The discussion in section 4.3.1 of the report (pages 13 and 14, WTG Size and Spacing) indicates there is 78 feet of clearance above the "water surface." The report then states that the largest (highest) vessel that routinely navigates Nantucket Sound, the ferry M/V Eagle, would have 9.4 feet of clearance should it approach a tower. Figure 4-10 defines water surface as "Mean Sea Level" which, for Nantucket Sound, is 1.5 feet lower than Mean High Water, the standard from which heights are measured by the National Oceanographic and Atmospheric Administration (NOAA). Further, at Mean High Water or Mean Higher High Water, the clearance for a vessel such as M/V Eagle will be somewhat (but significantly) less than 9.4 feet. (Given that the range of tide on Nantucket Sound is only about three feet, it appears there would still be sufficient clearance from a rotating blade). In other parts of the Assessment, particularly when referencing water depths, typical NOAA standards are used, i.e., water depths are measured from Mean Low Water. To be consistent, it is recommended that heights above water also conform to NOAA standards, which are measured from Mean High Water, not Mean Sea Level.

Appendix C-1

Environmental Impact Statement

Scope of Work

Wind Power Facility Proposed by Cape Wind Associates, LLC

This is the Corps of Engineers scope of work for the Environmental Impact Statement (EIS) to fulfill the requirements of the National Environmental Policy Act relevant to our review of the permit application for 170 wind turbines in Nantucket Sound. The Environmental Notification Form certificate issued by the state under the Massachusetts Environmental Policy Act (MEPA) on April 22, 2002 requires much of the same information necessary for the EIS. We are incorporating the MEPA scope and anticipating these additional topics are needed to ensure the items specific to NEPA are also included in the joint Environmental Impact Report/Environmental Impact Statement (EIR/EIS). This scope was developed based upon the comments received through the scoping meetings and letters received from the general public, special interest groups and local, state and Federal agencies. The intent is to list the issues to be addressed; more specifics on how to address them will be developed further through coordination with the cooperating agencies. This scope of work is expected to be a dynamic document and will evolve as our review progresses. We have attempted to include all issues raised into this scope. The permit decision will be based on the public interest factors listed at *33 CFR Part 320.4 General policies for evaluating permit applications* (http://www.usace.army.mil/inet/functions/cw/cecwo/reg/33cfr320.htm#320.4 .)

We will continue to meet with Cape Wind Associates, LLC representatives and the state and federal agency representatives to further develop the details of the alternatives screening and field studies and to review information as it becomes available.

The EIS must contain a complete discussion of scope and purpose of the proposal, alternatives, and impacts so that the discussion is adequate to meet the needs of local, state and federal decision makers.

The following organization and content of the Draft EIS (DEIS) can be adapted to allow for integration with the state's Environmental Impact Report. The items in bold text need to be clearly identifiable within the EIR/EIS to be evident that it fulfills the requirements of *33 CFR Part 325, Appendix B.*

The **cover** will identify the EIR/EIS as being a Corps permit action, state the regulatory authority and the Corps contact person.

A brief **Executive Summary** will include the Corps permit authority, Section 10 of the Rivers and Harbors Act, a summary of the purpose and need, alternatives, and both the beneficial and adverse impacts of the proposal. As the applicant's proposal is in a location that is unique with respect to the regulatory jurisdiction issues, each of the Corps of Engineers regulatory programs and their applicability and constraints, with respect to this proposal, will be summarized. A summary of mitigation actions will also be included.

Purpose & Need will be described in sufficient detail to indicate the geographic range of the alternatives analysis, and criteria to screen sites and power generation technologies which do not fulfill the project purpose & need. The purpose is to develop a commercial scale renewable energy facility providing power to the New England grid. The range for "commercial scale" will be described. We concur with MEPA's approach, including using New England as the geographic area. We will be reviewing information previously developed by the Massachusetts Renewable Energy Trust[1] to determine which renewable energy sources may be considered feasible at the commercial scale. Projections of future need for electricity, including the portion that should come from renewable energy sources based on regional, state and Federal requirements and policies will be included. The National Energy Policy recommendations will be included. Seasonal differences may need to be included. This will be compared to the projected power generation expected from existing facilities as well as those under construction. A brief description of the New England power grid, physical interconnection and the power market will be needed for context. Project description needs to include not only the structures but also the construction, operations and maintenance and decommissioning phases. Construction activities include transportation, staging, access, and any "onsite" assembly. A description of the pertinent state and federal regulatory authorities will include an explanation of the authorities of the Mineral Management Service for activities on the Outer Continental Shelf (OCS) and the applicability of the Clean Water Act. This is intended to inventory any existing or proposed legislation and any existing published federal policy addressing allocation of public resources of the OCS.

The **Alternatives** section will include reasonable terrestrial and offshore renewable energy facility locations, alternative cable routes and grid interconnection points which must be rigorously explored and objectively evaluated, as well as those other alternatives, which are eliminated from detailed study, with a brief discussion of the reasons for eliminating them. Initial alternatives will include alternative renewable energy technology, and alternative commercial scale generation capacity in addition to alternative terrestrial and offshore wind energy sites. Alternative technologies will include wind, tidal, solar, biomass, and hydroelectric. As was stated in the MEPA scope, based on Council on Environmental Quality (CEQ) guidance, only reasonable

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[1] The Renewable Energy Trust was created by the Massachusetts Legislature as an essential component of efforts to restructure the electric utility industry and to promote the development of renewable energy in the Commonwealth. The legislative goal is to "generate the maximum economic and environmental benefits over time from renewable energy to the rate-payers of the Commonwealth through a series of initiatives which exploits the advantage of renewable energy in a more competitive marketplace. It is completely independent of any project proponent.

alternatives need to be considered in detail. These do not need to be limited to those available to the applicant. The **no action alternative** may be either an alternative not involving Corps jurisdiction or denial of the permit. Onsite modification of, or siting of individual structures within, the final site(s) will be discussed as minimization of impacts after final site selection. Appropriate mitigation measures for the final alternative site(s) will be included. We expect a large number of alternatives will be quickly screened based upon criteria which will include, but not be limited to, ISO New England interconnection, wind quality mapping of 4 or better for wind sites, available land/water area, tide/wave/water depth conditions, legal/regulatory constraints, water quality criteria, engineering limitations, designated shipping channels, and environmental concerns. The screening criteria are being developed with input from the cooperating agencies. The EIS will include the criteria used to screen sites, and a summary of the screening process. The cooperating agencies have been asked to provide suggested alternatives in addition to those provided though the public scoping comment period. The initial list of sites will include potential "Brownfield" site reuse, Massachusetts Military Reservation/Otis AFB, expansion of other wind power sites such as Redington, ME and Searsburg, VT, public lands such as National Forest in New Hampshire, paper company lands in Maine, and private lands in addition to those already evaluated by the project proponent. Offshore wind and/or tidal power sites will include three locations within Nantucket Sound, Block Island area, south of Martha's Vineyard, east of Cape Ann, Maine coast and near shore industrial/urban areas. We will screen these alternatives to develop a short list of reasonable alternatives for site specific evaluation. Grouping of sites may be considered if small but otherwise potentially suitable sites are in close proximity. This screening of alternatives will be coordinated with the cooperating agencies. These will be in addition to the alternatives required by the MEPA scope for the EIR.

Affected Environment will describe the existing resources of the final alternative sites in terms of physical oceanography and geology; wildlife, avian, shellfish, finfish and benthic habitat; aesthetics, cultural resources, socioeconomic conditions, and air and water quality. Human uses such as boating and fishing will also be described. For terrestrial sites, other uses such as hiking or hunting may be appropriate.

Environmental consequences will describe the potential direct, indirect and cumulative impacts of each of the final alternative sites. In addition to the topics required by MEPA the following will need to be addressed:

Avian Impacts –The Study will describe the current use of the final alternative sites by birds, in order to establish a baseline data set. The species, number, type of use, and spatial and temporal patterns of use should be described. Information derived from other studies, which provides a three-year baseline data set, should be included if available. Information should be based on (1) existing, published and unpublished research results, especially research that describes long-term patterns in use, and (2) new field studies undertaken for this EIR/EIS. Data on use throughout the year, especially through November for migratory species, and under a range of conditions should be collected. Data collection methods should include remote sensing through radar and direct observations through aerial reconnaissance and boat-based surveys. Data gathered through radar should be validated with direct observations. The survey schedule is being coordinated with United States Fish and Wildlife Service (FWS). Data collection should allow a statistically rigorous analysis of results.

Known impacts to birds from former or current Wind Turbine Generators (WTGs) and other tall, lighted structures (such as communications towers) should be thoroughly reviewed in order to identify potential impacts which could result from terrestrial or coastal structures. Issues needing to be addressed include: (1) bird migration, (2) bird flight during storms, foul weather, and/or fog conditions, (3) food availability, (4) predation, and (5) benthic habitat and benthic food sources.

The Biological Assessment required for compliance with Section 7 of the Endangered Species Act will be a clearly identifiable section. The species to be addressed include Piping Plover, and Roseate Tern. Published data on avian impacts available from existing offshore facilities will be included.

Marine habitat impacts assessment should include vibration, sound, shading, wave disturbance, alterations to currents and circulation, water quality, scouring, sediment transport, shoreline erosion (landfall) and structural habitat alteration. Marine mammals and turtles to be addressed include northern right whale, humpback whale, fin whale, harbor seal and grey seal, loggerhead sea turtle, Kemp's Ridley sea turtle and leatherback sea turtle. Physical and acoustical impacts during construction and operation need to be assessed. The Biological Assessment required for compliance with Section 7 of the Endangered Species Act will be a clearly identifiable section.

Assessment of *fisheries and benthic impacts* needs to specifically address the requirements for an Essential Fish Habitat Assessment per the Magnuson Stevens Act. Studies for all final sites should include an assessment of: 1) species type, life stage, and abundance; based upon existing, publicly available information, 2) potential changes to habitat types and sizes; and 3) the potential for turbines as fish aggregating structures. The study should assess potential indirect impacts to fish, mammals, and turtles that may result from changes in water movement, sediment transport, and shoreline erosion. The study should include an assessment of potential impacts on specific fishing techniques and gear types used by commercial and recreational fishermen. The study should identify all potential conflicts with existing fishery use patterns and the potential for fishery elimination due to the consequences of the presence of the structures. The study should include a review of existing literature and databases to identify and evaluate commercial and recreational fish data and abundance data in Nantucket Sound. Data to be reviewed should include: National Marine Fisheries Service(NMFS) Commercial Data, NMFS Recreational Data, Massachusetts Division of Marine Fisheries Commercial Data, Massachusetts Division of Marine Fisheries Trawl Survey Data and supplemented with intercept surveys. The potential for indirect impacts such as changes in fishing techniques, gear type and patterns will need to be included.
The benthic field studies will provide sufficient information to compare between alternative marine sites and to provide a general characterization of the benthic habitat of the final sites. The data will include the Benthic Macroinvertebrate Community

Assessment (October 2001) and additional data collection will be as described in the Benthic Sampling and Analysis Protocol (April 18, 2002) supplemented by the ESS letter of May 10, 2002.
The EIS will attempt to comprehensively address the interconnections between the benthic, fisheries and avian resources. The predator-prey interactions are important considerations in fully understanding the potential impacts in siting a project within Nantucket Sound.

Aviation-Once a final alternative site is established for the wind farm and for each of the turbine towers an application will need to be submitted for a determination by the Federal Aviation Administration (FAA) that the activity will not cause an unacceptable interference with air navigation. FAA will need the precise coordinates of each tower. Their review will address lighting requirements, and radar interference and radio frequency interference as described in their letter of April 12, 2002. This review may require 6 months. It is highly recommended that this process be concluded and a determination made so this information can be included in the DEIS. The lighting scheme will need to minimize impacts to birds while also providing for safe aviation. Possible impacts to *telecommunication* systems vary with the different telecommunication technologies utilized in the area, and need to be considered. Microwave transmission typically requires "line of sight" between towers; installation of the wind turbine generators between Martha's Vineyard, Nantucket, and the mainland may interfere with existing transmission paths. Boaters in Nantucket Sound use a variety of communication devices including cellular phones, pagers, and VHS radios. The EIS will consider the possible impacts on existing and proposed communications equipment.

Commercial and recreational *navigation* impacts need to be addressed specifically for construction, operation and maintenance and decommissioning. Cable installation activities will be included. The Corps of Engineers will be working with the U.S. Coast Guard (a cooperating agency on the EIS) to insure that navigation impacts both to commercial and recreational boating, including the impact on sailing vessels and commercial fishing vessels, will be adequately addressed. A Coast Guard risk assessment for the overall wind farm project and a port navigation assessment may be needed. Appropriate lighting will be addressed. National security issues may be included based upon further coordination with the Coast Guard and Navy.

Socio-Economics-This project's possible impacts on electricity rates and reliability in New England and the local area need to be described. Explanation of any public funding and any applicable tax credits has been requested. Explanation of how this may affect the local economy including affects to employment, tourism, boating and fishing, coastal property values and local tax revenues and other fiscal impact to local governments needs to be included. The EIS will contain information relative to compliance with Executive Order 12898 "Federal Actions to address Environmental Justice in Minority Populations and Low-income Populations." Comments have suggested that new educational or tourism opportunities be explored.

Aesthetic and Landscape/Visual- the assessment as described by the MEPA scope needs to include documentation (an Appendix) of how the simulations were developed. We concur with the approach of using the locations as specified by MEPA. Visual impacts to any National Register-eligible site in proximity to any of the final alternatives will need to be included.

Cultural resources-needs to fulfill the requirements of Section 106 of National Historic Preservation Act including coordination with the State Historic Preservation Officer. In addition to the MEPA requirements we will need to determine the "area of potential effect". Any impact on historic districts, buildings, sites or objects, local character and culture, tradition, and heritage will be included. Archeological surveys may be needed for the final site(s). Based on previous archaeological and geological investigations, Horseshoe Shoal has the potential to contain evidence of prehistoric settlement and use. The Wampanoag Tribe of Gay Head has indicated that there may have been fishing or whaling equipment used in that area. The *Bibliography for Historic and Prehistoric Nantucket Indian Studies* by Elizabeth Little was provided by the acting Wampanoag Tribal Historic Preservation Officer. The reconnaissance level survey will need to address these points. A desk search of some of these sources of information will focus on Native whaling. For the final site, prior to permitting, magnetometer and high resolution side scan sonar surveys will be needed sufficient to provide electronic data which can be analyzed to assess the potential for any artifacts, such as shipwrecks, followed up by diver reconnaissance where needed. If resources are found which are eligible for listing on the Register of Historic Places, ways to avoid, then minimize, impacts to cultural resources will be considered and discussed. If avoidance is not an option, a Memorandum of Agreement may be required to mitigate potential impacts.

Recreation-Recreation impacts may be addressed within other sections such as the fisheries, navigation and aesthetics.

Due to the potential for underwater *noise and vibrations* associated with construction and operation of the facilities, some concerns have been expressed regarding the impacts on fish and mammal habitats and migration. The EIS should include an assessment of the magnitude and frequency of underwater noise and vibrations, and the potential for adversely affecting fish and mammal habitats and migration. It should also include an assessment of fish and mammal tolerance to noise and vibrations, with particular emphasis on noise and vibration thresholds that may exist for each of the species. The EIS will also include the potential of noise impacts to human activity at any of the final sites.

The *water quality* section should include a description of the potential for spills of contaminants into waters of the United States and the measures such as an emergency response plan to mitigate impacts. The installation technique for the cables and affect on water quality will be described. The types of materials to be used in the water such as stone, metals, concrete, etc. and likely effects of interactions between water/encrusting organism/sediment will be assessed.

Electric and magnetic fields (EMF)-Concerns have been raised about the potential human health impacts of exposure to 60Hz EMF, as some studies have suggested a possible link between EMF and health risks. The potential impact from electric and magnetic fields produced from wind turbine generators and their associated cables, and the transmission cable, will be considered. The Massachusetts Energy Facilities Siting Board has previously accepted EMF levels at the edge of a transmission right-of-way of 85 milligauss(mG). The EIS should identify populations that could be exposed to 60 Hz EMF greater than 85mG, including human, fish, marine mammals, and benthic organisms. There are particular concerns about possible locations for the landfalls of transmission lines and the EMF should be specifically evaluated at those locations.

Air and climate-The EIS will include a description of compliance with the requirements of the Clean Air Act for construction and operation phases. Any potential for impact on the climate of the region should also be addressed.

Safety considerations will include public and employee safety through construction, operation and decommissioning. Design standards for the structures will be explained.

List of preparers will include the names and qualifications of persons who were primarily responsible for preparing the EIS and agency personnel who wrote basic components of the EIS or significant background papers must be identified. The EIS should also list the technical editors who reviewed or edited the statements.

Cooperating Agencies and their role in the EIS will be listed.

Public Involvement will list the dates, locations and nature of all public notices, scoping meetings and hearings. The scoping meeting transcripts and summary of comments report will be provided as an appendix.

Acronym List-will define all commonly used acronyms within the text of the EIS.

Index will provide easy reference to items discussed in the main text of the EIS.

Appendices will include the lengthy technical discussions of modeling methodology, and baseline studies of the affected environment.

STEPS TAKEN TO ADDRESS NAVIGATIONAL SAFETY IN THE CONSENT REGIME FOR ESTABLISHMENT OF WIND FARMS OFF THE UK COAST[1]
8 July 2003

Introduction

1. The following procedures are recommended for all offshore wind farms planned, constructed and operated under United Kingdom authority. It is intended that they are followed within the consents process under section 34 of the Coast Protection (CPA) 1949 with section 36 of the Electricity Act (EA) 1989; and when maritime aspects of the Transport and Works Act (TWA) 1992 are being assessed. As regards the EA, maritime concerns are focussed upon the burying of cables taking power to the shore. The above routes also need a license under section 5 of the Food and Environment Protection Act (FEPA) 1985.

2. The MCA reserves the right to vary or modify these standards on the basis of experience and in accordance with internationally recognised standards in the interest of safety of life at sea and protection of the marine environment.

3. The development of wind farms off the UK coast necessitates establishing a clear consent regime to deal with effects that would be possibly detrimental to the safe navigation of vessels and shipping. The consent regime must take account of national standards and local factors that could influence the establishment of a wind farm. International aspects of the regime need also to be considered.

Actions required of wind farm developers

4. The consent regime shall require developers to take the following steps;

4.1 Undertake an up to date traffic survey of the area concerned. This must include not only all commercial traffic, but also fishing vessels and pleasure craft. The traffic survey should be properly representative of traffic in the area and is likely to be of at least four weeks duration, taking account of any seasonal variation in traffic patterns. Consultation with appropriate clubs, representative organisations for recreational craft and fishing federations will provice a more complete picture of seasonal variations.

4.2 Conduct a safety risk assessment of the relative siting, alignment and orientation of wind farm structures with vessel traffic flows in the particular area. The risk assessment should be used as the basis against which the following options can be assessed:

(i) no wind farm in the area;
(ii) a wind farm with conditions such as the establishment of an emergency management system including a shutdown procedure and a safety zone around the wind farm; or
(iii) a wind farm with no conditions.

4.3 Identify in the risk assessment should be tailored to the area concerned and should demonstrate the following items and factors:

(i) knock-on changes to traffic patterns arising through vessels' re-routeing to avoid the wind farm, including subsequent any new areas of convergence, bunching,

[1] Includes United Kingdom internal waters, territorial waters and in any future area for their development under UK jurisdiction established beyond territorial waters (a renewable energy zone).

choke points and the creation of new points where crossing traffic converges or directs marine traffic closer towards hazards, so endangering craft, their cargoes, crews and passengers;

(ii) increase in risk of collision between vessels and wind farm structures (including turbine blades) under all reasonably foreseeable weather and tide height conditions or between vessels under all conditions [2];

(iii) limitation on the use of such sites or adjacent waters for non-transit purposes. e.g. fishing, day cruising, racing, aggregate dredging, anchoring etc.;

(iv) co-operation with local and national search and rescue authorities, taking into consideration the types of vessels and equipment that would used and search patterns;

(v) national requirements and procedures employed for turbine shutdown and how rotor blade rotation and power transmission might best be controlled by emergency services (standards copied at Annex 1);

(vi) emergency use of the structures by persons seeking refuge and rescue balanced against reasonable levels of security;

(vii) foreseeable interference with shipboard systems particularly radio systems, such as caused by reflections or phase-changes with respect to aids to navigation, ship/shore radar and Automatic Identification Systems (AIS);

(viii) problems for rescue services, including obstructions to use of helicopters and lifeboats;

(ix) preserving access for servicing of adjacent aids to navigation;

(x) radar reflections, blind spots and shadow areas created by structures;

(xi) sonar interference caused by the structures and the generators;

(xii) electromagnetic fields created by the generators or cabling, affecting compasses and other navigational systems;

(xiii) visual blocking view of the coastline and other navigational features such as buoys and lights;

(xiv) tidal streams that could cause vessels to set into danger in the event of power or steering failures;

(xv) other adverse effects on the set and rate of tide;

(xvi) siltation, deposition of sediment or scouring created by the structures such as to affect the navigable depth of water; and

(xvii) wind masking turbulence or sheer created around structures and impacting on vessels nearby.

4.4 Demonstrate through the risk assessment the increased risk to navigation from the proposed siting of the wind farm and the effectiveness of proposed protective measures designed to mitigate that additional risk. Examples of protection measures for ship's routeing purposes are given in Annex 2.

5. In considering the results of the developer's risk assessment the competent authority (the MCA) will assess whether the site for the wind farm represents an acceptable increase in navigational risk to enable granting of the consent, made conditional if necessary on the developer taking and maintaining specified protective measures.

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[2] A minimum safe (air) clearance shall be maintained between sea level conditions at mean high water springs (MHWS) and the turbine blades that:

.1 is suitable for all vessel structures of vessels involved in current maritime traffic flows and operations; and additionally

.2 is no less than 18 metres.

The proposed wind farm could pose problems at high water that do not exist in low water conditions.

6. In assessing the need for protective measures and safety zones with reference to the traffic surveys, risk assessment (referred to above) and expert opinion, developers may include recommendations for the vessel safe operating distances from the structures. These may include the size and types of vessels and those activities that may continue to operate and exercise rights of navigation.

7. In navigable waters, if the appropriate protective measures include safety zones around structures and subsea cables the safety of navigation and any persons involved in working on the structures shall be the primary validation. Existing users' rights and activities may be interfered with only so far, as:

> .1 is necessary for purpose of safety, with avoidance of the blanket use of 'Exclusion Zones'; and
>
> .2 when Protection measures are consistent with the principles of Article 60 of the UN Convention on the Law of the Sea (UNCLOS) (copied at Annex 3).

8. An application for consent should also indicate the contractors' proposals on how to bring evidence of breach against any navigational advice or requirement established in association with protective measures, to the attention of MCA or other relevant body to take action as appropriate. The application should also outline the methods to be employed by the developer for promulgating necessary safety information to vessels that operate in the vicinity of the wind farm [3].

9. In the event of protective measures being required, the MCA will advise the developer whether international agreement for them is necessary. When so advised, the developer will be required to support and co-operate with the MCA at the International Maritime Organization (IMO) for the introduction of such measures. (Recognised standards for the establishment of safety zones and safety of navigation around offshore installations and structures are contained in IMO Resolution A.671(16))

10. Consent granted by the MCA shall indicate that the proposal meets suitable national and international standards for the navigational safety of wind farm developments, providing that any conditions specified in the consent are met.

11. Additional consideration of safety factors not included in this document will be required for projects that utilise offshore wave, tidal power or any future offshore structures necessary for renewable power generation.

12. National points of contact on navigation safety issues:

Navigation safety, pollution at sea and search and rescue concerns - MCA

Aids to navigation, in England and Wales - Trinity House
In Scotland – The Commission of Northern Lighthouses
In Northern Ireland – The Commissioners of Irish Lights

Safety on the offshore structures - The Health and Safety Executive
Charting and hydrographic information – The United Kingdom Hydrographic Office
Within the limits of the harbour authority – Local harbour authorities

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[3] Developers will promulgate information (e.g. footprint diagrams) on any detrimental affects to propagation of ship and shore radio, aids to navigation, radar and Automatic Identification Systems (AIS).

10. All MRCC/SCs will have a chart indicating the GPS position of each of the WTGs in all wind farms.

Operational Procedures

11. Upon receiving a distress call or other emergency alert from a vessel who is concerned about a possible collision with a WTG or is already close to or within the wind farm, the MRCC/SC will establish the position of the vessel and the identification numbers of any WTGs which are visible to the vessel. The position of the vessel and identification numbers of the WTGs will be passed immediately to the Central Control Room.
12. The control room operator will immediately initiate the shut-down procedure for those WTGs as requested by the MRCC/SC, and will maintain the WTG in the appropriate shut-down position again as requested by the MRCC/SC until receiving notification from the MRCC/SC that it is safe to restart the WTG.
13. The communication and shutdown procedures must be tested satisfactorily at least twice a year.

*Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers.

Annex 2

Examples of additional Marine Routeing Safety Measures to establish in association with wind farms during operation

Measures are to be consistent with international standards contained in SOLAS Chapter V, IMO Resolution A.572(14) and Resolution A.671(16).

A – Lower risk wind farms
All of the structures situated in areas with less than 3 metres of water below chart datum away from all shipping routes, channels, recognised fairways and significant levels of other maritime activity including recreational craft and fishing vessels.

Associated Routeing Measures:
Dissemination and promulgation of information through radio-warnings and notices to mariners, including details of the nature of activities that should not be carried out within a specified range of the structures and any adverse effects upon navigational systems.

B – Medium risk wind farms
All of the structures situated in areas with less than 7 metres of water below chart datum away from all shipping routes, channels, recognised fairways, but may be associated with other maritime activity including recreational craft and fishing vessels.

Associated Routeing Measures:
Dissemination and promulgation of information through radio-warnings and notices to mariners.
Safety zones up to 50 metres from the structures with monitoring by radar and a continuous watch by multi-channel VHF including DSC. Appropriate measures to notify and provide evidence of infringements of safety zones.

C – Higher risk wind farms
Structures situated in areas with more than 7 metres of water below chart datum close to or across shipping routes, channels and recognised fairways.

Associated Routeing Measures:
Dissemination and promulgation of information through radio-warnings and notices to mariners.
Safety zones up to 50 metres from the structures with monitoring by radar, AIS transponders at the extremities and a continuous watch by multi-channel VHF including DSC.
Use of a guardship or guardships to provide a visible indication of the limits of a safety zone, to alert other mariners when they may be running into danger and to share in the task of monitoring the safety of the wind farm.
Area to be avoided (ATBA) around the whole of the wind farm and up to 500 metres from the extremities preventing access to a range of craft (e.g. vessels of over 300 GT, of over 25 metres in registered length or carrying dangerous or polluting goods) and marine activities.
Continuous vessel monitoring/information service using radar/AIS and radar by appropriately training staff.
Closure of nearby shipping routes where there are suitable alternatives (subject to consultation)
Other routeing measures will be considered where warranted by traffic patterns. Appropriate procedures in place to notify and provide evidence of infringements ATBAs or safety zones.

Annex 3

Article 60 UNCLOS
Artificial islands, installations and structures in the exclusive economic zone

1. In the exclusive economic zone, the coastal State shall have the exclusive right to construct and to authorize and regulate the construction, operation and use of: (a) artificial islands; (b) installations and structures for the purposes provided for in article 56 and other economic purposes; (c) installations and structures which may interfere with the exercise of the rights of the coastal State in the zone.
2. The coastal State shall have exclusive jurisdiction over such artificial islands installations and structures, including jurisdiction with regard to customs fiscal health, safety and immigration laws and regulations.
3. Due notice must be given of the construction of such artificial islands, installations or structures, and permanent means for giving warning of their presence must be maintained. Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organization.
Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed.
4. The coastal State may, where necessary, establish reasonable safety zones around such artificial islands, installations and structures in which it may take appropriate measures to ensure the safety both of navigation and of the artificial islands, installations and structures.
5. The breadth of the safety zones shall be determined by the coastal State, taking into account applicable international standards. Such zones shall be designed to ensure that they are reasonably related to the nature and function of the artificial islands, installations or structures, and shall not exceed a distance of 500 metres around them, measured from each point of their outer edge, except as authorized by generally accepted international standards or as recommended by the competent international organization. Due notice shall be given of the extent of safety zones.
6. All ships must respect these safety zones and shall comply with generally accepted international standards regarding navigation in the vicinity of artificial islands, installations, structures and safety zones.
7. Artificial islands, installations and structures and the safety zones around them may not be established where interference may be caused to the use of recognized sea lanes essential to international navigation.
8. Artificial islands, installations and structures do not possess the status of islands. They have no territorial sea of their own, and their presence does not affect the delimitation of the territorial sea, the exclusive economic zone or the continental shelf.

Ship Collision Risk for an Offshore Wind Farm

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ABSTRACT: The Danish government has presented extensive plans for reducing the CO_2 emissions by developing and improving renewable energy. Among these alternative energy sources wind energy is the most profitable. One of the problems with wind turbines is that they disfigure the landscape and the new trend is therefore towards large offshore wind farms. The present paper focuses on the ship collision risk analyses and the established model for calculation of the collision frequencies for the wind farms. In order to calculate the collision frequencies, issues as ship traffic, navigation routes, geometry of the wind farm and the bathymetry in the area are addressed. The ship collision frequencies forms the first step in an evaluation of whether the location is optimal from a ship collision point of view and moreover, the analysis forms the basis for marking the wind farm or the area around it in order to decrease the collision frequencies.

1 INTRODUCTION

The Danish government has presented activity plans stating that the CO_2 emission should be reduced with 20% by year 2005 as compared to 1988. In order to achieve this, the ratio of renewable energy should be increased and because wind energy is the most profitable the focus has been put here. The problem with wind turbines is that they disfigure the landscape and the new trend is therefore towards large offshore wind farms located more than 10 kilometres from the coastline. Besides the aesthetic benefit the offshore wind climate is better with larger mean wind velocity and less turbulence.

The Danish power supply company SEAS has been asked to carry out preliminary investigations for constructing wind farms at Rødsand south of Lolland in the Baltic Sea and at Omø Stålgrunde south of the Great Belt Link between Zealand and Funen. These wind farms comprise 72 turbines each with the size of approximately 2 MW giving a total capacity of 150 MW per wind farm. Besides the wind turbines the wind farm comprise internal cable connections, a trafo-module and cable connections to shore. The trafo module is the most vital part of the wind farm and a ship collision against the trafo module will stop the power supply from the whole park. Construction, installation and start of the wind farms are planned to take place in the period 2003 to 2005. The focus in the present paper is on the wind farm at Rødsand, but except from local conditions as the water depth and ship traffic, the described procedure is general.

The wind turbines at Rødsand will be constructed in a 9×8 grid with a distance between each of the wind turbines of 875 m x 475 m, which means that the entire wind farm will cover an offshore area of approximately 6.1 km × 3.8 km.

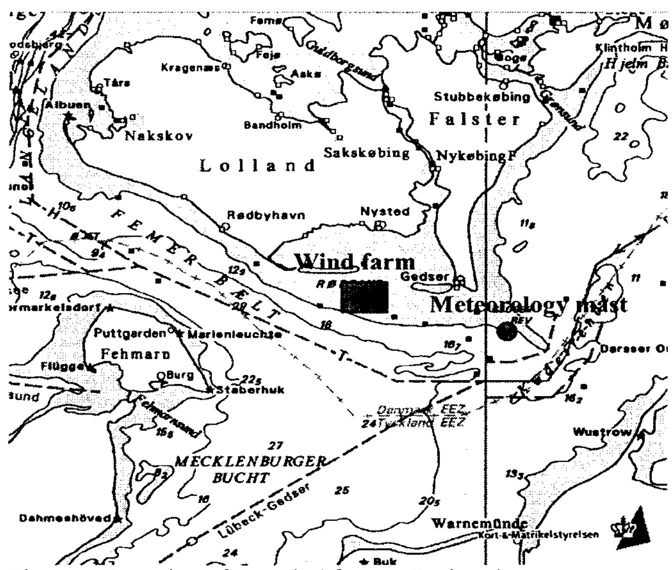

Figure 1. Location of the wind farm at Rødsand.

The wind farm is located 12 kilometres south of Nysted on Lolland and the distance from the border of the wind farm to an international navigation route (the T-route) is 8 kilometres. This international route

Appendix F-1

is one of the most trafficked seaways in the Danish waters with approximately 46000 ship passages per year. The location of the wind farm and the T-route is shown in Figure 1.

The T-route is a typical center marked navigation route, but 6 kilometers east of the wind farm there is traffic separation where ships from north through Øresund meats with the east – west going traffic. At the traffic separation the navigation route is both side-marked and center-marked. The way of marking influences the position of the ship traffic.

In Figure 2 the actual position of the wind turbines is shown together with the position of the trafo-module and the power cable between the trafo-module and the shore.

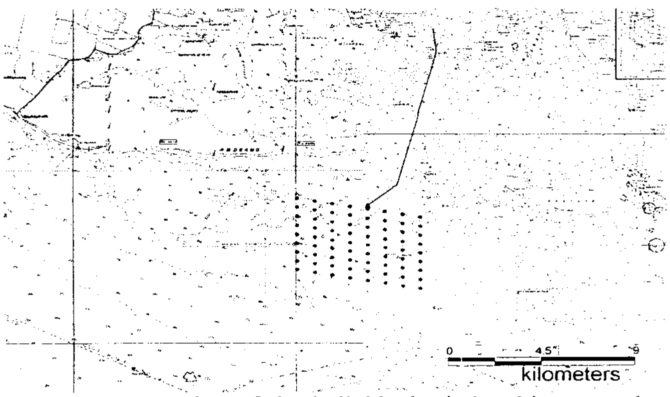

Figure 2. Illustration of the individual wind turbines together with the power cable to shore for the wind farm at Rødsand.

The construction cost for an offshore farm is much higher than a wind farm constructed on land and it is therefore important to evaluate whether the location is optimal. The optimal position is here seen from a ship collision's point of view. The present paper is focused on the ship collision risk analyses and the established model for calculation of the collision frequencies for the wind farms. The analyses therefore deal with:

- Ship traffic, the number of ships and the distribution of the position of the ship traffic in the area near the wind farm.
- Navigational routes in the vicinity of the wind farm.
- Wind, waves and current conditions in the area, which are important for drifting ships.
- Geometry of the wind farm and the bathymetry in the area.

The present ship traffic will be described in terms of quantity, ship class distributions and probability distributions for their position in the sailing route.

The procedure for the calculation and the decision strategy is shown in the flow diagram given in Figure 3.

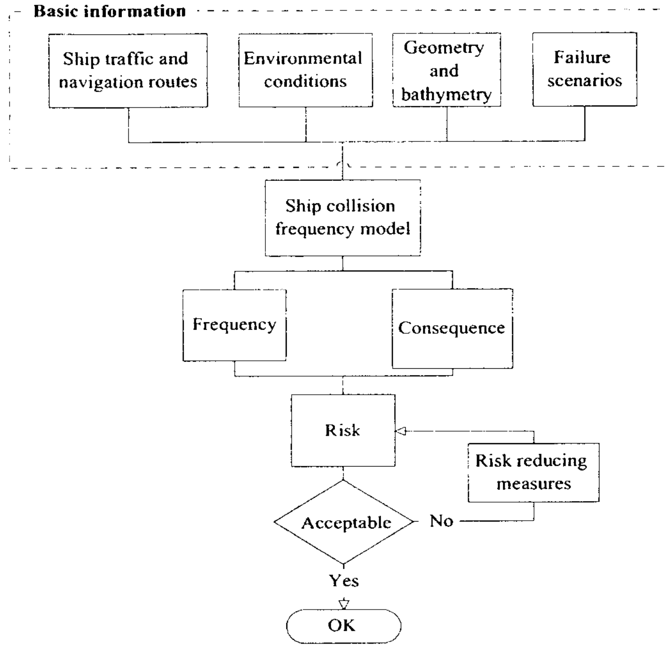

Figure 3. Flow diagram of the calculation procedure.

2 SHIP TRAFFIC AND NAVIGATION ROUTES

The ship traffic at Rødsand consists mainly of ships passing through the Femern Belt and from the Baltic Sea. In order to describe the ship traffic in the area around the wind farm, the annual ship movements on different navigational routes have been estimated on basis of data for the ship traffic. These data have been collected from the ports in the Baltic Sea, VTS (Vessel Traffic Service) registrations in the Great Belt and in Øresund and the traffic through the Kieler Canal. A number of navigational routes have been defined and the yearly number of ship movements on each of these routes has been estimated on basis of the collected data. The navigational routes considered are sketched in Figure 4.

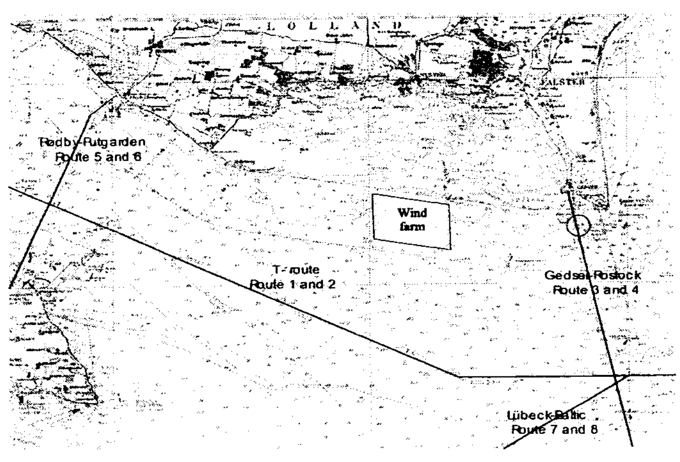

Figure 4. Navigation routes around the wind farm at Rødsand.

There are 4 main waterways in the vicinity of the wind farm, which corresponds to 8 navigational routes when the sailing direction is taken into account. The most important route (denoted 1 and 2) is the international navigation route called the T-route. The guaranteed water depth in the T-route is 19 metres. The other routes (3-4 and 5-6) are ferry routes between Denmark and Germany located on each side of the wind farm with the distance 10 and 21 kilometres. The last route (7-8) is between Lübeck in Germany and the Baltic Sea. The ship traffic is described with respect to the number of yearly movements and the ship size distribution in GRT and is based on the information from the pilots and port authorities, the Kieler Canal and the VTS registrations.

In Table 1 and Table 2 is shown the navigational route and corresponding number of yearly ship movements distributed on ship classes. The relations between ship class and GRT, ship length, draft and width of ship are based on statistical data from Lloyds Register of Ships and this statistical base are used in the frequency calculation.

Ship class	*GRT*	*Femern-Baltic*	*Baltic-Femern*	*Gedser-Rostock*
Route	-	1	2	3
1	0-250	1904	1904	0
2	251-500	1577	1577	0
3	501-1000	1767	1767	0
4	1001-1500	1679	1679	0
5	1501-2000	1657	1657	0
6	2001-3000	2282	2282	0
7	3001-4000	4331	4331	995
8	4001-6000	4882	4882	236
9	6001-10000	2882	2882	1169
10	10001-25000	806	806	927
Total	-	23773	23773	3327

Table 1. Annual traffic distribution on the first three routes and the relation between ship class and GRT.

Ship class	*Rostock-Gedser*	*Rødby-Putg.*	*Putg.-Rødby*	*Lübeck-Baltic*	*Baltic-Lübeck*
Route	4	5	6	7	8
1	0	0	0	22	22
2	0	0	0	22	22
3	0	0	0	78	78
4	0	0	0	243	243
5	0	0	0	243	243
6	0	1144	1144	415	415
7	995	0	0	620	620
8	236	0	0	982	982
9	1169	17520	17520	2517	2517
10	927	0	0	1685	1685
Total	3327	18664	18664	6827	6827

Table 2. Annual traffic distribution on the last five routes.

The number of fishing vessels in the area is very modest and the size of these fishing vessels is also limited, and it is hence assumed that the fishing vessels are too small to cause major damage on a wind turbine. The fishing vessels are therefore not included in Table 1 and Table 2.

3 MODEL FOR SHIP COLLISION

In order to determine yearly collision frequencies for the wind farm and the trafo-module, a model has been constructed taking into account the variability of the exact ship location along the considered routes, human errors, failure on propulsion machinery and steering failure, (Fujii 1983, Larsen 1993).

For the determination of the collision frequencies for the wind farm, it is assumed that any ship that due to one of the above-mentioned failure modes will be located within the area of the wind farm will collide with one of the turbines in the park area. The frequency is thus determined as the frequency that the ship will be within the wind farm area due to one of the failure modes. All types of collisions whether it will be a direct collision on a turbine or a glancing off when touching the turbine are considered as a collision.

The geometry of the wind farm and the trafo-station is modelled together with the bathymetry in the vicinity of the wind farm. The water depth in the wind farm varies between 5.0 and 8.6 metres.

The ship traffic is assumed to sail parallel to the ideal navigation routes. The ship location perpendicular to the navigation route is assumed to follow a distribution given as a uniform plus a Gaussian distribution. The ration between the to distributions is taken to be 2% uniform and 98% Gaussian, (Pyman 1983).

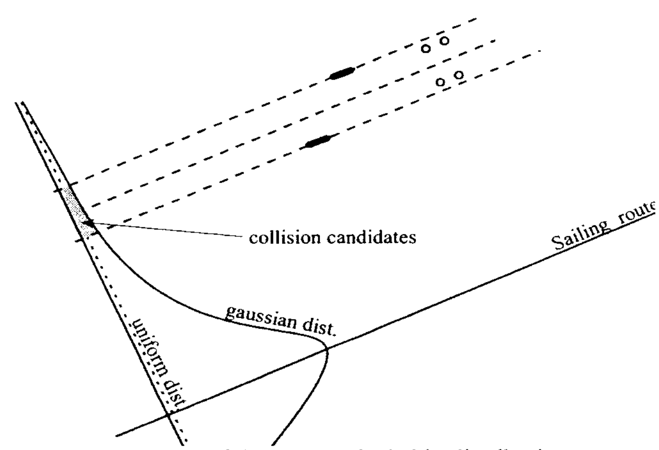

Figure 5. Illustration of the geometrical ship distribution.

The 3 parameters in the combined distribution for the 8 navigation routes are given in Table 3. The standard deviation in the Gaussian distribution will in general depend on whether the navigation route is center-marked or side-marked, where a center-marked navigation route as in this case yields the largest deviation.

Navigation	Gaussian		Uniform
Route	Mean	Std. deviation	Length
1	0 m	1200 m	13000 m
2	0 m	1200 m	13000 m
3	0 m	500 m	8000 m
4	0 m	500 m	8000 m
5	0 m	500 m	6000 m
6	0 m	500 m	6000 m
7	0 m	1200 m	14000 m
8	0 m	1200 m	14000 m

Table 3. Parameters in the geometrical model for the ship distribution transversely to the navigation routes.

The three collision scenarios: human errors, failure on propulsion machinery and steering failure are considered. A short description of the three scenarios is given in the following.

Human failure

If a human failure shall result in a ship collision the following two restrictions must be fulfilled. The ship has to be on collision course, i.e. have direction towards the wind farm or the trafo module, and the ship will have to maintain this course until collision, thus no actions are taken in order to prevent the collision. The probability that the collision course is maintained is denoted "the probability of human failure".

Steering failure

When the steering system of a ship fails, the rudder will be locked and the ship will start sailing into a circular path. The diameter of the circle depends on the locked position of the rudder and the underkeel clearance. According to general experience, a full deflection of the rudder is the most typical result of a failure of the steering system and this scenario is considered in the present study.

Failure on propulsion machinery

A failure on propulsion machinery will cause the ship to start drifting. The drift direction is as a first case assumed to be likely in any direction. The drift direction will though depend on the distribution of the current and wind direction. If the drifting direction is towards the considered wind farm, a sideways collision will occur, i.e. a ship without steering velocity will start to drift sideways. The two other scenarios will result in a head on bow collision.

In modelling the collision frequencies for the drifting ships it has been taken into account that the reaction time from being a drifting ship to information of the relevant authorities and arrival of a tugboat in order to stop the drifting ship will take a minimum of 10 hours. This assumption limits the maximum drift distance at Rødsand to approximately 18 kilometres.

The probabilities and other parameters used in the three scenarios are given in Table 4, (Fujii 1983, Macduff 1974, Pedersen 1995) and verified in (Karlsson 1998).

Scenarios	Parameter	Value
Human error	Probability for human error	2×10^{-4} per passage
	Duration of error	20 minutes
Steering failure	Probability for steering failure	$6{,}3\times10^{-5}$ per hour
	Sail radius	2,5×ship length
Failure in propulsion machinery	Probability for drifting ship	$1{,}5\times10^{-4}$ per hour
	Anchoring probability	0,7

Table 4. Used probabilities and parameters in the three collision scenarios.

4 SHIP COLLISION FREQUENCIES

Combining the stated failure modes and the traffic description the collision frequencies can be obtained.

It is found that drifting ships, i.e. ships having failure on propulsion machinery drifting towards the wind farm, are the largest contributors to the collision frequencies. A ship with failure on its propulsion machinery will drift sideways in a direction that depends on current and wind direction. The ship collision frequencies related to human failures, i.e. navigational errors, absence of navigator etc. are very modest due to the large distance (around 8 kilometres) between the wind farm and the navigation routes. Moreover, it is found that by and large all the ship collision frequencies are related to ship movements on the routes nearest to the wind farm with most traffic, i.e. route 1 and 2 (the T-route). The collision frequencies and the corresponding return periods are given in Table 5. There is no contribution from steering failure due to the large distance and the two scenarios thus also correspond to the two collision types "head on bow" collision and "sideways" collision (drifting ship).

Collision scenarios	Frequency	Return period
Drifting ships	1.8×10^{-1}	6 year
Human failure	7.1×10^{-9}	1.4×10^{-8} year
Total frequency	1.8×10^{-1}	6 year

Table 5. Collision frequencies and return periods for the wind farm at Rødsand.

From Table 5 it is seen that the collision frequency is governed by the contribution from drifting ships.

In Figure 6 is the collision frequencies shown as a function of ship class. The largest parts of the ship collision frequencies are related to rather large ships (between 3000 to 25000 GRT). The contribution from ships larger than 25000 GRT vanishes due to the limited water depth. For ships in this range of GRT it is not practically possible and economically reasonable to design the wind turbine to resist a ship collision.

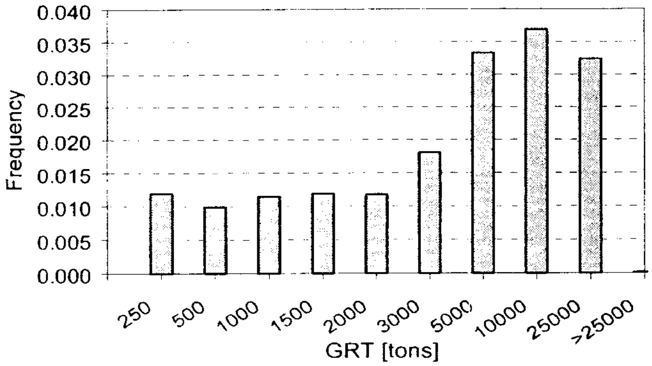

Figure 6. Collision frequencies as a function of ship size (GRT) for the wind farm at Rødsand.

Moreover it is seen that ships with GRT less than 3000 contributes significantly to the collision frequencies with approximately 40%. For ships of this size it is possible to design the turbine to resist a collision, but the additional expenditures should of cause be considered.

The colliding ships corresponding to the size distribution are typically different types of cargo ships (tankers, container vessels, bulk carriers, etc.).

4.1 *Sensitivity study*

As seen from Table 5 the contribution from human errors is very close to zero. This is due to the assumption that all ships will follow the T-route with a given deviation. This may not necessarily be true because by sailing closer to the cost a significant shortcut can be made. Such a route is possible for all ships with a draught less than 4 metres. A sensitivity study, where one fifth of the traffic with a draught less than 4 metres is assumed to follow a parallel shifted route 6 kilometres further north closer to the wind farm, is being carried out.

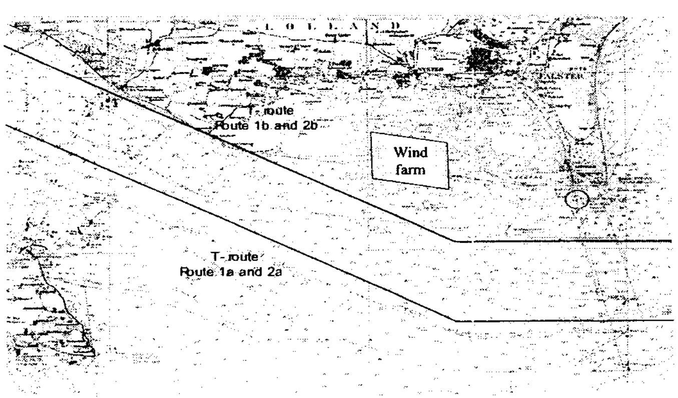

Figure 7. Navigation route in the sensitivity study.

The parallel shifted route is shown in Figure 7. For this parallel shifted route the standard deviation in the Gaussian distribution has been decreased from 1200 metres to 800 metres and also the width of the uniform distribution is decreased from 13000 meters to 8000 meters due to the shorter distance to the shore.

The ship traffic on the new route and the reduced traffic on the original route are shown in Table 6.

Ship class	*Femern-Baltic*	*Baltic-Femern*	*Femern-Baltic*	*Baltic-Femern*
Route	1a	2a	1b	2b
1	629	629	1275	1275
2	460	460	1117	1117
3	998	998	769	769
4	1493	1493	186	186
5	1494	1494	163	163
6	2246	2246	36	36
7	4313	4313	18	18
8	4886	4886	2	2
9	2882	2882	0	0
10	806	806	0	0
Total	20207	20207	3566	3566

Table 6. Annual traffic distribution on the route 1a and 2a, and the shifted route 1b and 2b used in the sensitivity study.

Based on the new traffic distribution the collision frequencies can be obtained. The results are given in Table 7.

Collision scenarios	Frequency	Return period
Drifting ships	2.1×10^{-1}	5 year
Human failure	3.6×10^{-3}	300 year
Steering failure	1.6×10^{-5}	60000 year
Total frequency	2.1×10^{-1}	5 year

Table 7. Collision frequencies and return periods for the sensitivity study for the wind farm at Rødsand.

From Table 7 it appears that if some of the ships have a tendency to make a shortcut and sail closer to shore instead of following the international T-route, the contribution from "human failure" can become significant.

SEAS have therefore carried out some measurements of the traffic in the area in order to identify a better estimate of the different ships' navigation routes. This is described in Section 7.

5 VERIFICATION OF THE OBTAINED SHIP COLLISION FREQUENCIES

As part of the risk analysis a registration of known actual ships' accidents was performed. The information was obtained for "Søværnets Operative Kommando" (the Navy) in Denmark and covered a period of 10 years from 1990 to 2000. In Figure 8 is given a map showing the registered accidents.

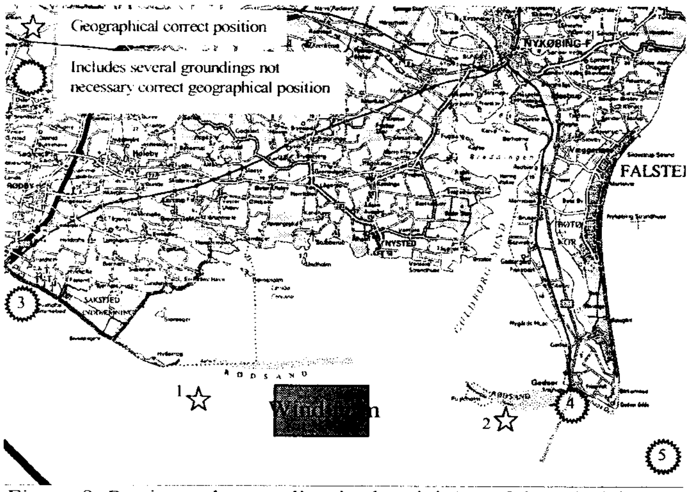

Figure 8. Registered grounding in the vicinity of the wind farm.

It follows from Figure 8 that two groundings have occurred in the vicinity of the wind farm during the investigated period of 10 years. Comparing this to the obtained return period of approximately 6 years for the wind farm indicates that the obtained frequencies for the wind farm seams reasonably.

6 SHIP COLLISION AGAINST METEOROLOGY MAST

In 1996 SEAS established a measuring mast on Gedser Reef approximately 21 km east south east for the new wind farm at Rødsand. The water depth at the location, which is in between the T-route and Gedser, is approximately 6.5 metres. Just north of the mast the reefs can be passed by ships with a draught of less that 6 metres, and at every location on the reef the water depths is deeper than 4 metres.

The measuring mast is a 48 metre high steel mast founded on a steel system rammed into the seabed. The mast is marked with light and is visible both visually and on the radar.

A ship has collided with the mast twice in 1998 and 2000. The first time resulted in minor damage only. The second time the mast was severely damaged and it was necessary to remove the mast and foundation completely. In 1998 the ship, a coaster of approx. 1500 DWT, collided with the mast at night in rough weather conditions and bad visibility. It has not been possible to identify the ship, which was involved in the second collision, hence it has not been possible to clarify the special conditions relating to this accident.

During the investigation of the accidents it was observed that a large number of ships both east and west bound, with a DWT up to 2000-3000 DWT, passes Gedser Reef north of the T-route.

7 MEASURING PROGRAMME OF SHIP TRAFFIC CLOSE TO THE WIND FARM

The sensitivity analysis carried out as part of frequency analysis shows that the risk of a ship collision with the wind farm will increase significantly if the ships pass north of the T-route. Based on the results of the frequency analysis and the registration of the collisions with the measuring mast, it was decided to carry out a detailed measuring programme for the ship traffic.

Radar observations were performed along two lines as shown in Figure 9, and the number and locations of ships passing the lines were registered in the autumn of 2000.

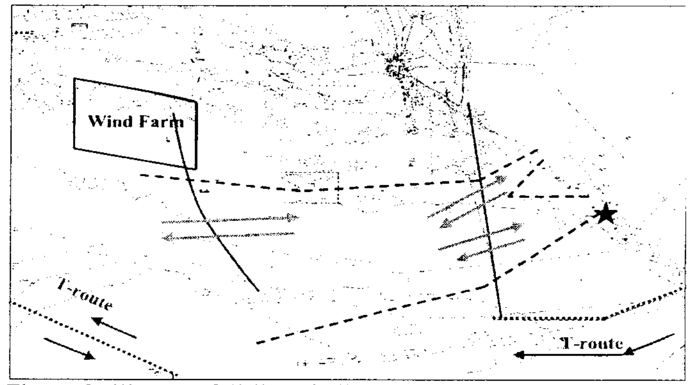

Figure 9. The two full lines indicate where the radar observations were carried out. The dashed lines indicates the deviation of the traffic and the arrows indicates where the central part of the traffic is located on these lines (preliminary results).

In the period from October to November 2000, a total number of 516 passages were observed, this corresponds to 6 to 7 per cent of the total traffic through Femern Belt. Preliminary evaluations of the data show that a significant part of the ships pass very close south of the new wind farm, and it is the intention to perform a more detailed analysis of the data at the beginning of 2001. The results of this analysis will form a basis for an update of the risk analysis for ship collisions against the wind turbines and the trafo-module.

8 RISK REDUCING MEASURES

The results of the updated risk analysis may lead to proposals for introduction of risk reducing measures. Such measures could be:

- Different types and markings
- Protective arrangements (especially for the trafo-module)
- VST monitoring or guard vessels

The marking is the most economical manageable but the effect of marking is not known. There is a risk for the ships would uses the markings as way-points and hereby actually increase the risk of a collision because the ships will pass closer to the wind farm. The use of way-points will be examined through interviews with captains on minor ships.

The protective arrangements could be consider for the very vital trafo-module.

9 CONCLUSION

As a first step the resulting yearly collision frequencies for the wind farm and trafo module is calculated and different risk reducing strategies are considered. Based on the first analysis a measuring program is established and an analysis of the use of way-points are initiated. Based on these results the risk of a ship collision should be reevaluated and the need of further risk reducing measures considered.

The overall conclusion from the present study, is that it is of great importance to initiate risk analysis activities at an early stage of a project, to ensure that proper action can been taken in the detailed design phase if any needs are identified.

The analysis shows that "thinking risk" from the start makes it possible to identify problem areas and areas with importance for the design of the project. Such areas could be actual ship traffic distribution, location of trafo-module etc.

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Risk of Oil Pollution due to Ship Collision with Offshore Wind Farms

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Summary

The present paper describes the methodology in determining the risk of oil pollution due to ship collision with offshore wind farms. The work have been carried out by RAMBØLL for A/S Elsam in connection with the plans of constructing offshore wind farms at various locations along the Danish coast. The yearly frequencies of ship collisions with an offshore wind farm have been found and consequences in terms of oil spill scenarios related to the collisions are determined. Finally, the risk of oil pollution of the West Coast of Jutland have been found on basis of the ship collision frequencies and the oil spill scenarios.

Keywords: Ship traffic, probability of ship collision, oil spill scenarios, environmental impact, risk analysis

1. Introduction

The Danish government has presented activity plans stating that the CO_2-emission should be halved at year 2030 compared to 1988. To achieve this, the ratio of renewable energy should be increased, and one of the objectives is offshore wind farms. The Danish companies A/S Elsam and Eltra A.m.b.A have together been given the responsibility of constructing wind farms at Horns Rev in the North Sea and south of Læsø in Kattegat. A/S Elsam and Eltra A.m.b.A. are responsible for the wind farm and for the 132 kV cable connection to the shore, respectively. Construction, installation and start of the wind farms are planned to take place in the period 1999 to 2003. The wind farm at Horns Rev will be located approximately 40 km west of the city of Esbjerg. A total of up to 80 wind turbines will be constructed, giving a total capacity of 150 MW. The turbines will be constructed in a 10×8 grid with a distance between each of the turbines of 560 m, which means that the entire wind farm will cover an offshore area of approximately 4 km × 5 km. The turbines will be connected internally by a 20 kV cable in a radial configuration. All turbines are hooked to a transformer station (trafo station) placed at a single platform. The trafo station is connected to the electricity grid on land by a 132 kV offshore cable. The location of the wind farm is shown in Figure 1. The present paper focuses on the risk of oil pollution on the coast of Jutland as a consequence of ship collision with one of the turbines or the trafo station, and describes the results of the set of analyses that have been carried out in order to determine possible oil pollution. The results of the analyses have been used as input to the risk evaluation in the EIA-description and to the risk analysis of the entire project including risk of damage of the cables due to trawling activities. For this reason it has been reasonable to make a number of assumptions in order to simplify the model.

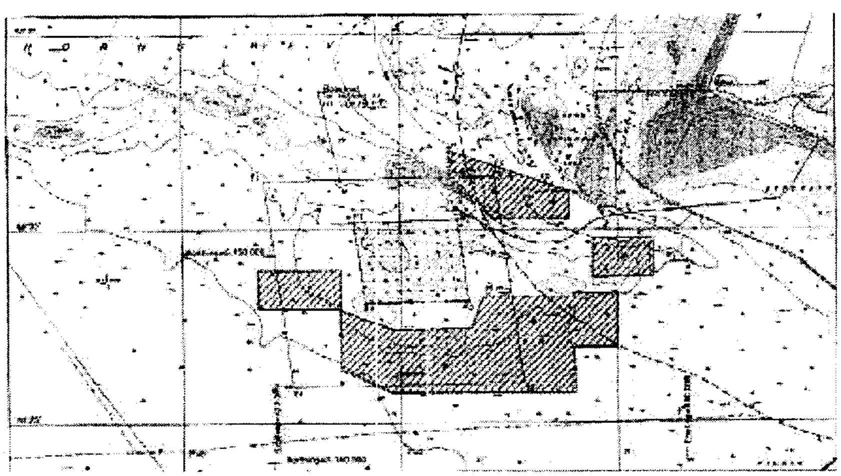

Figure 1 Location of the wind farm at Horns Rev

In a later stage these assumptions have been evaluated and more detailed analyses have been carried out if necessary. This has for instance been done for the probability-based design of the wind turbines and foundations.

The risk assessment are based on a set of analyses carried out step wise. These analyses are dealing with

- The determination of annual ship traffic in the area
- The determination annual ship collision frequencies
- Instant consequences of a ship collision (oil spill scenarios)
- The consequences of an oil spill (oil pollution scenarios)

In the following sections these items will be described separately.

2. Annual ship traffic in the area

The ship traffic at Horns Rev consists mainly of ships going to and from the port of Esbjerg and of ships from Scandinavia and the Baltic Sea heading for ports in Northern Germany. In order to describe the ship traffic in the area around Horns Rev, the annual ship movements on different navigational routes have been estimated on basis of data for ship traffic. These data have been collected from ports in Denmark, Scandinavia and Northern Germany. Besides the ordinary ship traffic of commodity ships and ferries, there is a number of fishing ships in the area. In the port of Esbjerg, there are 112 fishing ships of various sizes. It is assumed that small fishing ships will depart and arrive almost every day, while the larger fishing ships will go further away and will have less yearly arrivals and departures compared to the small fishing ships.

A number of navigational routes have been defined and the yearly number of ship movements on each of these routes has been estimated on basis of the collected data. There are 5 main navigational routes in the vicinity of Horns Rev. Three of the routes lead the ship traffic to and from the port of Esbjerg. One route is going through Slugen north of Horns Rev between the inner and the outer reef, one is going south of Horns Rev and one is going between Esbjerg and the English Canal. The last two routes are the routes west of Horns Rev in northern and southern direction, respectively. The description of the ship traffic with respect to the number of yearly movements and the size distribution (GRT) has been divided into commodity ships including ferries and fishing ships. The commodity ships. On basis of information from port authorities, the commodity ships are placed on the various routes. It is assumed that the largest part (80%) of the fishing ship movements will go on the routes north or south of Horns Rev towards the North Sea , while the remaining 20% will go on the southern route towards the English Canal. The navigational routes are sketched in Figure 2 together with the estimated number of annual movements on each of the routes. The numbers in brackets are annual ship movements including fishing ships.

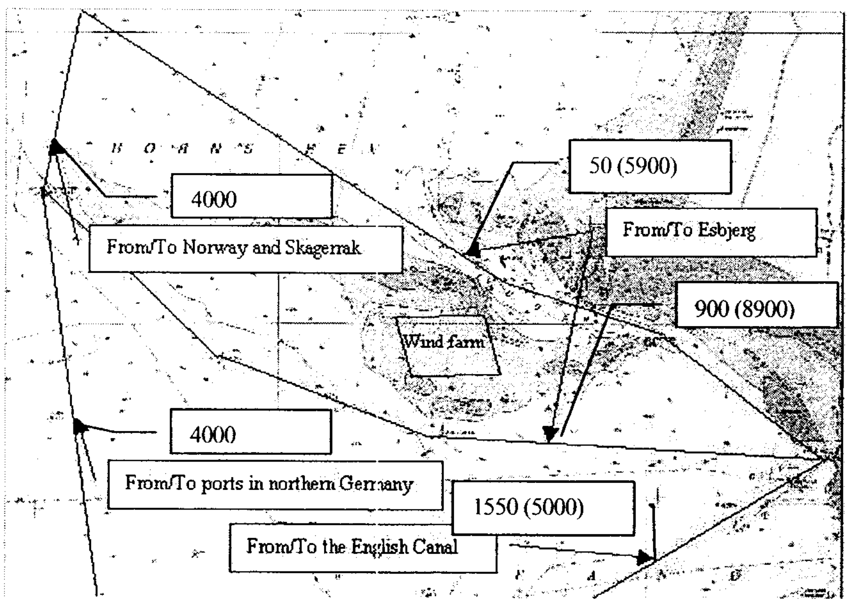

Figure 2 Navigational routes and markings at Horns Rev

3. Ship collision frequencies

In order to determine the yearly collision frequencies for the wind farm and the trafo station, a calculation model has been constructed taking into account

- The variability of the exact ship location along the considered routes, Ref. [1], [2] and [3]

- Human errors, Ref. [6]
- Failure on propulsion machinery and steering failure, Ref [4] and [5].

Furthermore, a geometric modelling of the wind farm and trafo station have been made. The wind farm has been modelled as a box, and it is assumed that any ship entering the area within the box due to one of the above mentioned failure scenarios will collide with one of the turbines. The combination of the failure scenarios, the geometric modelling of wind farm and trafo station, the location of the navigational routes and the bathymetry in the area yields the following results:

- Drifting ships, i.e. ships having failure on propulsion machinery drifting towards the wind farm, are the largest contributors to the collision frequencies. A ship with failure on propulsion machinery will drift sideways in a direction that depends on current and wind direction.
- A minor part of the ship collision frequencies are related to human failures, i.e. navigational errors, absence of navigator etc.
- The major part of the ship collision frequencies is related to ship movements on the routes nearest to the wind farm, i.e. the routes north and south of Horns Rev.
- The largest parts of the ship collision frequencies are related to small fishing ships (less than 250 GRT), but also ships with GRT-values of 2000-4000 tons contribute significantly to the collision frequencies. Ships of these sizes are typically the supply ships serving the offshore platforms in the North Sea. Minor contributions to the ship collision frequencies are seen for large ships with GRT-values of 15000 - 20000 tons. These ships are mainly the ships on scheduled liner traffic to and from the port of Esbjerg.

The calculated collision frequencies are based on the assumption that all ships entering the box area (the geometric model of wind farm area) will cause a collision. Thus, no consideration has been taken to the probability that a ship entering the area will leave the area again without colliding with any of the turbines. Furthermore, the glancing effect, i.e. a ship only touching a turbine and bouncing off, is disregarded. These conservative assumptions are made in the present analysis due to the fact that it is merely the ranking of the collision frequencies – and not the exact values - which are determining for selecting relevant oil spill scenarios. Finally, in modelling failures related to drifting ships, it has not been taken into account, that the navigator may regain control of the ship after a short while; either because the propulsion machinery is repaired or because of the presence of tug- or rescue boats.

It is therefore expected that the calculated collision frequencies are conservative estimates. The results in terms of return periods for different type of collisions and for different ship types are given in Table 1.

Table 1 Return periods for different collision scenarios

Collision scenario	*all ships*	*Commodity ships*
Drifting ships	3 years	22 years
Human failure	47 years	736 years
Total frequency	3 years	22 years

It is seen from Table 1 that the dominating contributions to the collision frequencies originates from the fishing ships, and also that collisions with drifting ships involved, are the dominating failure type.

4. Oil spill scenarios

If a ship collision has occurred, and if the collision leads to major hull damages, the consequence may be oil leakage from the tanks. On basis of the results of the ship collision frequency study, specific ship types with large contributions to the collision frequencies have been considered in the oil spill analysis. These are small fishing ships below 250 GRT, supply vessels for the offshore installations in the North Sea, ro-ro ships in regular liner traffic and tankers. For the three first, analyses have been made for leakage from bunker oil tanks while analysis of leakage from main storage tanks are made for oil tankers. The probability of a collision is given from the collision frequencies, while the probability that hull failure occurs can be estimated from considerations of energy exchange between the ship hull and the wind turbine structure during a collision.

4.1 Bunker oil spill

In order to determine possible spill volume from the bunker oil tanks, the connection between the ship size and type and the bunker volume in the tanks are estimated on basis of samples of corresponding values of GRT in tons and bunker oil volume in tons. These samples are taken from Lloyds Register of Ships. It is shown that bunker volumes can be expressed through a linear dependency to the ship size. However, oil companies serving the vessels in the port of Esbjerg with respect to filling the tanks with bunker oil have been contacted in order to verify the correspondence between GRT and bunker oil volume. According to these companies, the actual bunker oil volumes for the ships visiting the port of Esbjerg are less than the estimated. Since the information given by oil companies relates to the specific vessels expected to operate in area in the vicinity of Horns Rev, the oil spill leakage volumes are based on this information.

The way the bunker volume is stored in the ships is greatly varying from the various ship types. For most ships, the number of bunker oil tanks varies from 2 to 5. In the bottom of the ship, there will be some tanks of minor sizes, while the largest tanks are placed at the sides of the ship in the vicinity of the machine room. How these tanks are protected is also varying from ship to ship. For this reason, a conservative approach has been taken in order to determine the expected spill of bunker oil as a consequence of a ship collision with serious hull damages. Since the most likely scenario is a ship drifting sideways towards one of the mills damaging one of the main tanks on the side of the ship, it is assumed that from 30% - 50% of the total bunker oil volume will leak from the tanks.

4.2 Tanker oil spill

The port in Esbjerg has registered 117 arrivals of tankers in 1999. The tankers are primarily minor tankers with GRT values of 3000 - 5000 GRT. The largest tanker calling the port of Esbjerg in 1999 was 'Urengoy' of Russia with a GRT-value of 13204. The tankers are transporting various oil products and other products, such as jet fuel, gasoline, gas, melasse, fish products, methanol, ethanol and brine. Oil products are stored in a number of tanks - usually from 6 to 12 tanks depending on ship size. These tanks are either centre tanks located in the centre of the ship, or wing tanks located at the side of the ships. The centre tanks accounts for most of the volume. The volume of each of the tanks is depending on the size of the ship. The tankers of the most frequent sizes - 3000-5000 GRT - have typically 8-10 tanks with a total volume of 5000 - 8000 m^3. Conservatively, it is assumed that 30% of the total volume will leak into the sea as a consequence of the ship collision. Furthermore, the bunker oil tanks may leak as well and should be taken into account also when looking at oil spill scenarios from tankers. Since a relative large number of annual visits of tankers to the port of Esbjerg are registered, a ship collision scenario from a typical tanker are taken into account in estimating environmental impacts.

In Table 2 the ships involved in collision scenarios expected to appear most frequent or special collision scenarios with large environmental impact is shown. The total volume of storage tanks and the volume expected to leak into the sea are shown.

Table 2 Definitions of oil spill scenarios

Ship type	*GRT [tons]*	*Oil product*	*Total volume [m^3]*	*Expected leakage [m^3]*
Fishing ship	250	Bunker oil	40	20
Supply vessel	4000	Bunker oil	1000	500
Ro-Ro vessel	20000	Bunker oil	1000	500
Tanker	5000	Jet fuel+bunker oil	8000 + 1000	2500 + 500

There is a difference between characteristics of refined oil product as jet fuel and of bunker oil. Furthermore, there are a number of different types of bunker oil with various characteristics. The most common types of bunker oil amongst the samples taken from Lloyds Register of Ships are diesel oil and high viscosity fuel. Both of these are fuels with high specific gravity, while the jet fuel transported by tankers are much lighter.

5. Oil pollution scenarios

The calculations are carried out for average values for the environmental conditions. The drift of the oil is calculated based on [8], [9] and [10], but no considerations have been taken to the effect of the current, due to the fact that the current are dominated by tidal current moving the oil spill in north/south directions along the coast. The period of the tidal current is approx. 12 hours.

The results are given in terms of a probability that the oil will reach a given stretch of the coast. These probabilities are calculated on basis of the conditional event that an oil spill has occurred within the wind farm area. The calculations are based on average wind conditions. The current and wind data is covering a 9-month period from May 1999 until February 2000. The results of the spreading calculations are summarised in Figure 3.

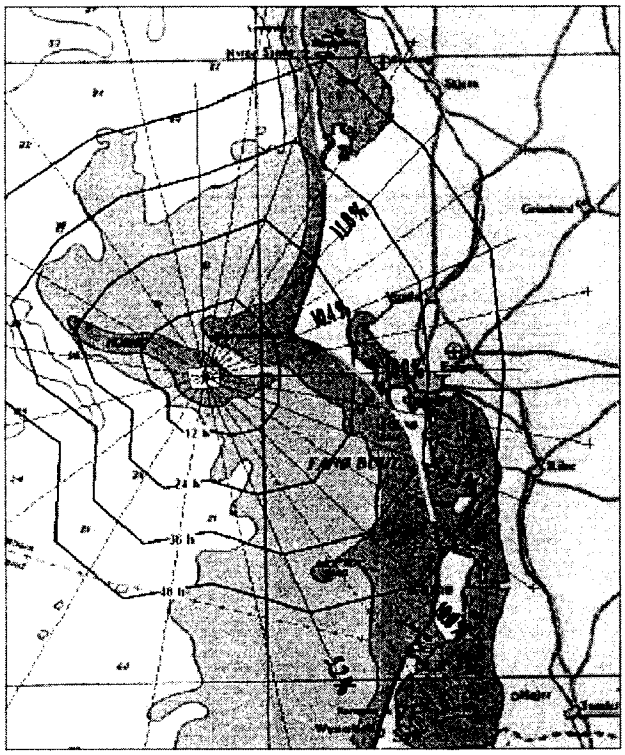

Figure 3 Summary of oil spreading calculations

It is found that the stretch of coast from Grådyb, Blåvands Huk and up to Vejers can be reached by the oil patch within 12 to 24 hours after a release. The probability for wind towards those locations is approx. 20 %.

The coasts are mainly sandy beaches. This type of coast is among the less sensitive and it is relatively easy to clean up. If the oil is trapped by the tidal current in Grådyb it will presumably be transported into Ho Bugt. This situation will cause more severe consequences.

Vadehavet between Fanø and Rømø is sensitive to oil pollution. The area can be reached within 36 to 48 hours after a release of oil. The probability of wind towards those locations is approx. 15 %.

An overview of the oil fate calculations which determine the quantities of the oil reaching the coast, for the different scenarios are given in Table 3.

Table 3 Overview of oil fate volumes in tonnes of oil on the beach and conditionally probabilities.

Location	Probability	Scenario A Fishing vessel 17 t diesel		Scenario B Supply vessel 425 t diesel		Scenario C Ro-Ro vessel 500 t bunker		Scenario D Tanker 2000 t jet fuel (500 t bunker not included)	
	%	summer	Winter	summer	winter	summer	winter	Summer	winter
Hvide Sande	9.2	≈0	≈0	<38	<60	405	435	<200	<240
Henne/Vejers	11.0	≈0	≈0	<38	<60	450	470	<200	<240
Blåvands Huk	10.4	≈0	≈0	98	123	470	485	460	560
Skallingen/Grådyb	10.0	≈0	≈0	38	60	455	475	200	240
Fanø	8.3	≈0	≈0	<38	<60	435	455	<200	<240
Rømø	10.0	≈0	≈0	<38	<60	400	425	(<200)	(<240)
Sylt	5.2	≈0	≈0	<38	<60	380	400	(<200)	(<240)

The consequences of oil pollution depend on the type of oil involved, Ref. [7] and[10]. Small quantities of diesel spill (release from fishing ships) will evaporate and disperse before it reaches the coast. In case of release of larger quantities of light fuel (e.g. jet fuel), the fuel can reach the nearest shoreline. However, by far the largest part of the fuel (up to 90 percent) will evaporate and disperse before it reaches the coast. Heavy bunker oil will remain in the water for a long period of time. Due to the predominant westerly wind it is likely that the bunker oil, one way or another will end on the Danish West Coast. However, it is possible that the bunker oil will sediment due to the high initial density.

6. Discussion, Conclusions and Acknowledgements

The resulting yearly collision frequencies and corresponding oil spreading results, i.e. oil fate volume and conditional probability, are presented in the Environmental Impact Assessment-report. This report is at present awaiting public comments. On basis of the comments or as a result of other initiated analysis projects connected to the offshore wind farm project, some of the basic assumptions may be re-evaluated and the modelling may be refined.

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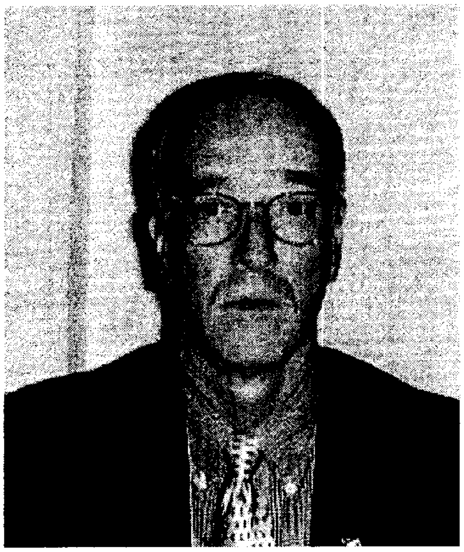

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Biographical Summary

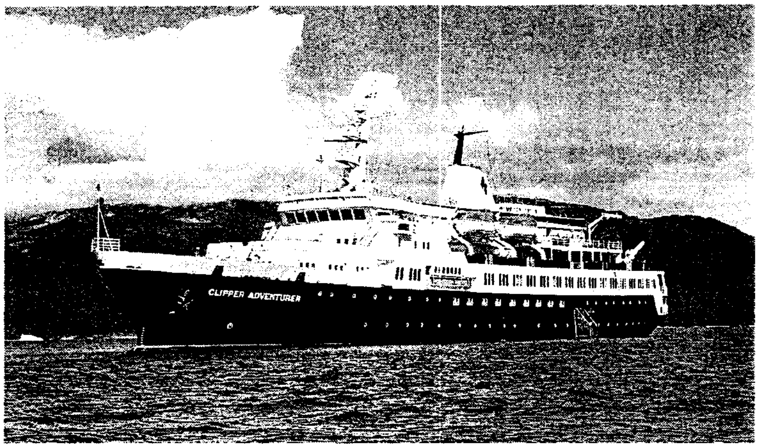
Jack McGowan's experience includes over 30 years in military and government service rising to the rank of Rear Admiral in the U.S. Coast Guard. RADM McGowan's last operational assignment was Commander, Ninth Coast Guard District, leading the region's 7,000 Coast Guard men and women in eight states bordering the Great Lakes.

Jack graduated from the Coast Guard Academy in 1969 and served aboard the USCG Cutter TAMAROA (chronicled in the "Perfect Storm") in New York followed by subsequent tours in Thule, Greenland and on all the coasts of the U.S. He has toured extensively advising shipping companies, port authorities and seafarers worldwide in maritime safety, security, navigation and port development matters. This experience culminated with Jack's formation of The MCGOWAN Group and its subsequent growth in international recognition. The MCGOWAN Group, LLC as a maritime consulting company, specializes in providing systems-approach integrated solutions to the toughest of challenges.

As delegate for the U.S., RADM McGowan negotiated several international codes and treaties and is a recognized expert in port security, development, ships' design, cargoes and personnel. He negotiated a model agreement, adopted by the U.N., to prevent the smuggling of migrants on the world's shipping. Jack served as Operations Officer on a cutter, Commander of a station above the Arctic Circle, "Deputy Mayor" of Governors Island, NY and as Captain of the Port for the coastlines of Maine and New Hampshire. He was the lead security and logistics coordinator for Presidents Reagan and Gorbachev's last meeting in New York harbor. RADM McGowan was the Director of shipping personnel responsible for security background, training and qualification standards for all U.S. seamen.

Jack implemented the U.S. Port State Control program noted by both the *Wall Street Journal* and the *Journal of Commerce* for its innovative risk-based, tracking of foreign ships calling on U.S. ports. Jack also served as Deputy Chief of Staff of the Coast Guard and was instrumental in the first major reorganization of the Coast Guard since WWII. RADM McGowan holds two degrees from the Massachusetts Institute of Technology and is a CAPSTONE Fellow of the National Defense University.

RADM McGowan is a published authority and has spoken on leadership in various arenas including those sponsored by the Pugh Foundation and by the FBI. He has received numerous awards including the Legion of Merit, the Secretary of Transportation's Gold Medal, the Bay of Fundy Visionary Award and recognized by the Vice-President's National Performance Review.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